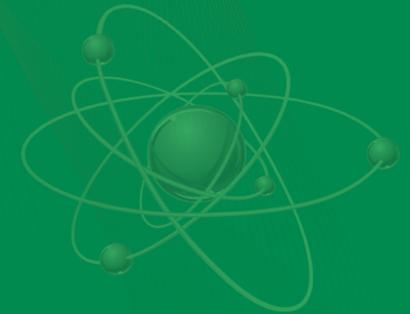
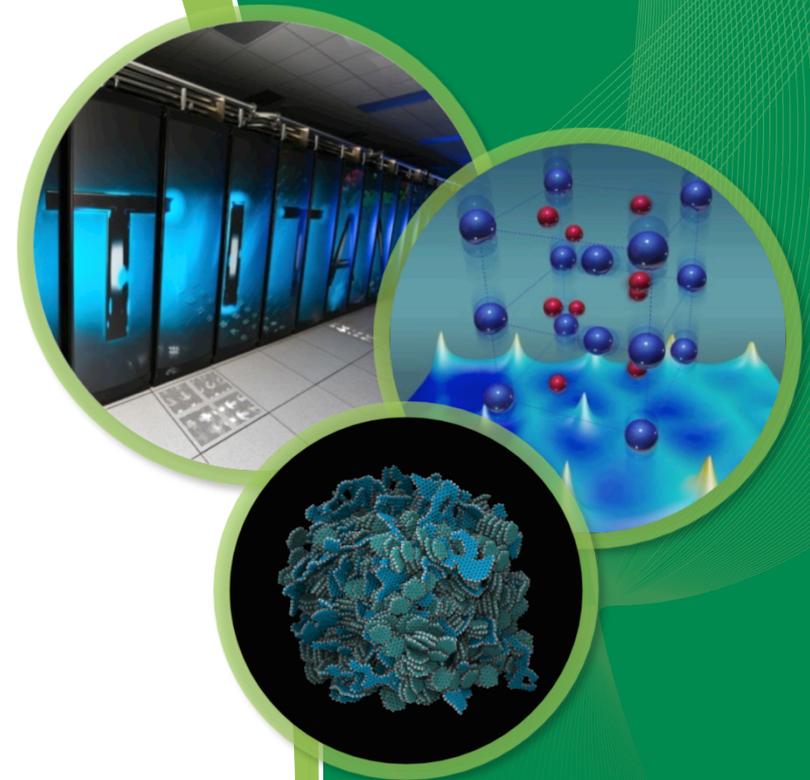


# Fulcrum User Interface

## Capability Introduction

Robert A. Lefebvre

October 2016



# Presentation Outline

- Fulcrum Mission Statement
- Fulcrum Component Overview
- Fulcrum Input Editor
- Fulcrum Data Plotting
- Fulcrum Geometry Visualization

# Fulcrum Mission Statement

Provide a cross-platform graphical user interface (GUI) designed to facilitate problem creation, modification, navigation, validation, and visualization, as well as output and data file interaction as needed by new and experienced users.



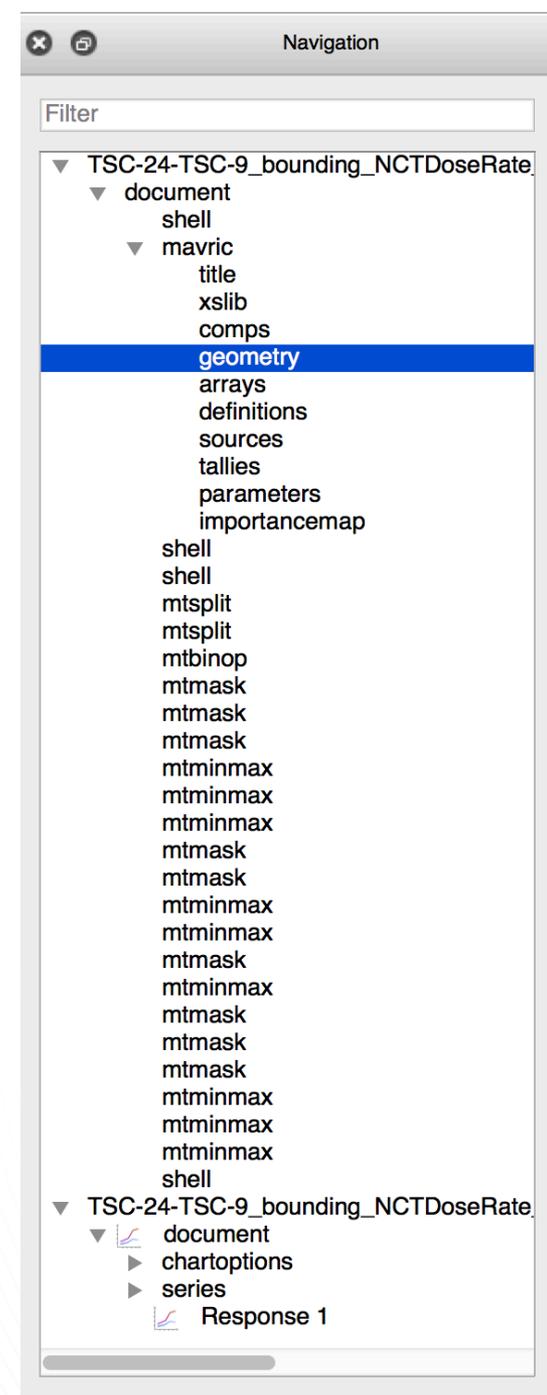
# Fulcrum Component Overview

The screenshot displays the Fulcrum software interface with several key components highlighted:

- Input Editor:** Shows a list of geometric objects and their properties. The highlighted row is:  
2228 | media | 9 | 1 | 1 | 2 | 19.290000 0. origin x=0.736600 y=0.736600
- Document Navigation:** A tree view on the left showing the project structure, including 'TSC-24-TSC-9\_bounding\_NCTDoseRate' and its sub-components like 'document', 'shell', 'mavric', and 'geometry'.
- Data Plot:** A scatter plot titled 'radial axis plot at a=6.1098, b=-1.9435 generated on Thu Jul 28 17:01:33 2016'. The y-axis is 'Responses' (log scale) and the x-axis is 'radial axis'. A blue box labeled 'Data Plot' is overlaid on the graph.
- Geometry Viewer:** A 3D visualization of the reactor geometry with a color-coded response distribution. A blue box labeled 'Geometry Viewer' is overlaid on the top right of the view.

# Fulcrum Document Navigation

- Hierarchical Listing of Document
  - Quick Navigation to input component
  - Plot creation
- Open Associated Files
  - Lists files with matching extension-less filename
  - streamlines opening associated files
- Filter
  - Regular expression based item filtering
- Dockable
  - Dock to main Fulcrum application
  - Float in separate window
  - Hide completely



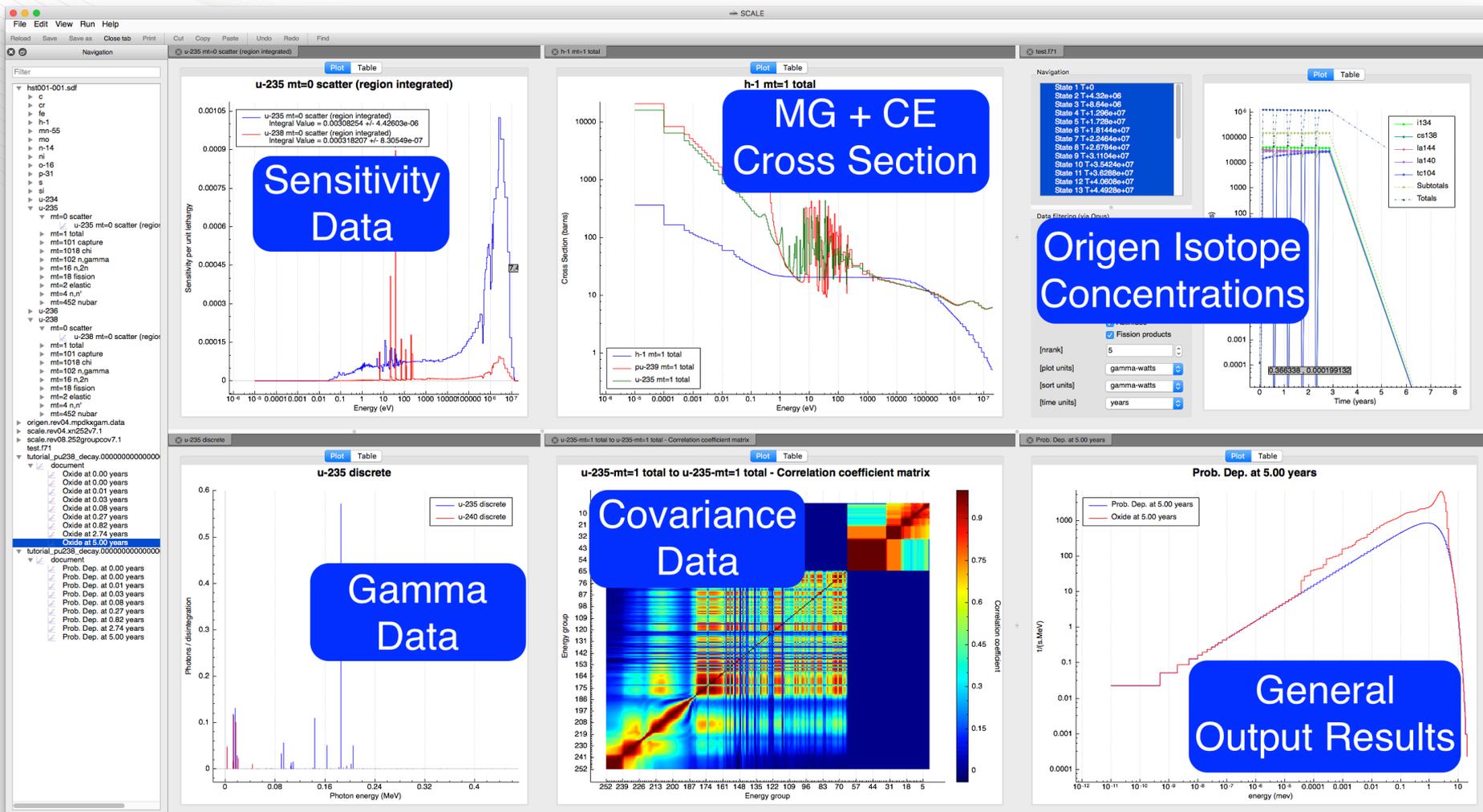
# Fulcrum Input Editor

- Syntax Highlighting
- Top Level Quick Navigation
- Cursor Context
- Preserves User Input Format
- Current Input Block Highlight
- Input Autocompletion
- Input Validation
- Customizable Input Execution

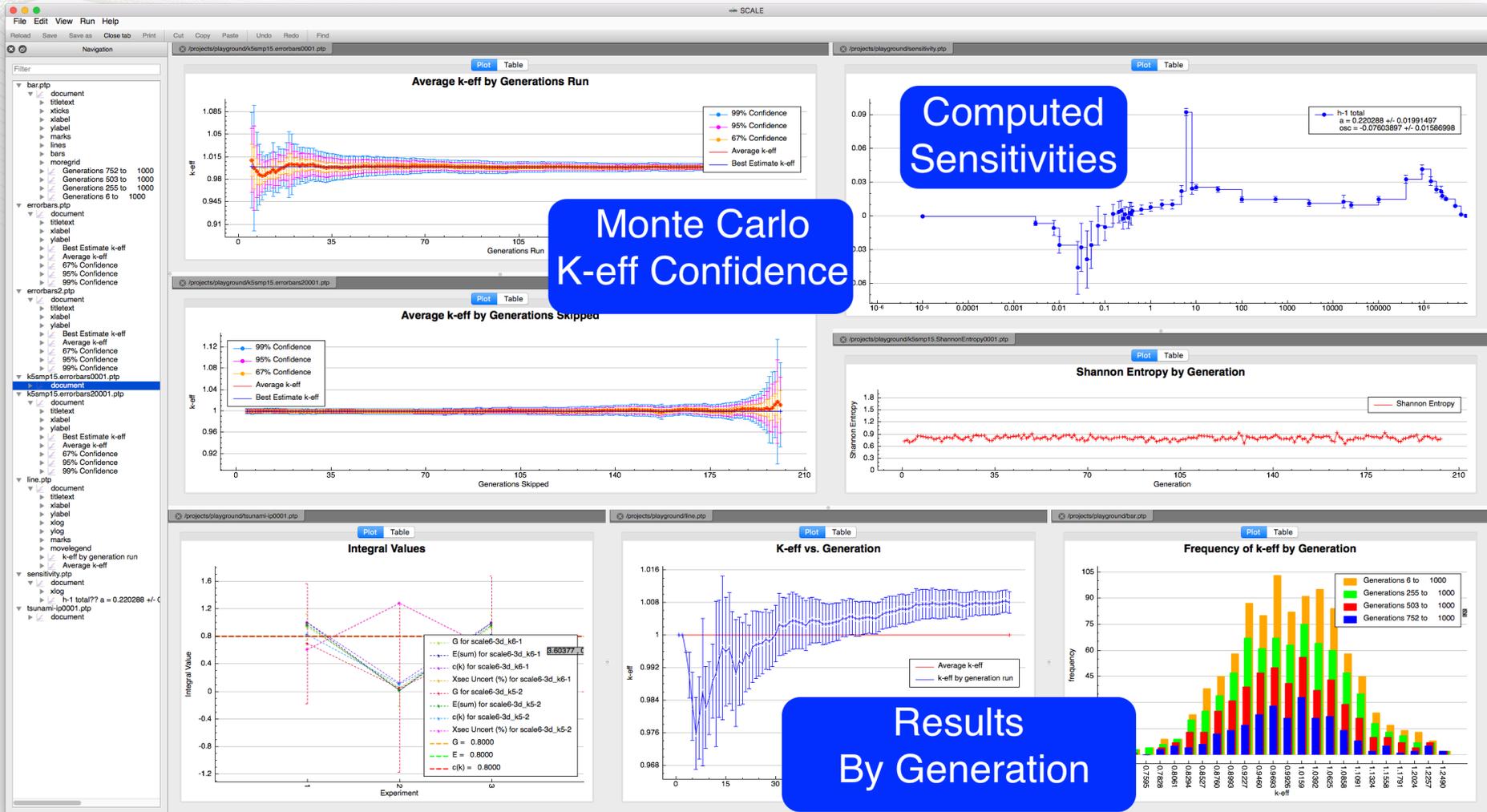
The screenshot shows the Fulcrum Input Editor interface. The title bar displays the file name 'TSC-24-TSC-9\_bounding\_NCTDoseRate\_02-02-2004.inp\*'. The menu bar includes 'comps', 'SCALE 6.2', 'Run', 'View...', and 'Edit...'. The main text area contains code with syntax highlighting. Line 1810 is highlighted in yellow and contains the text: `u02 1431 den=10.0538 1 293.00 92234 0.0271 92235 4.04 92236 0.0140 92238 96.9190 end`. Below the code, two error messages are displayed in a blue bar: `line:1810 column:1 - Validation Error: name value "u02" is not one of the allowed values: [ ... "u-241" "u-242" "u-uo2" "u232-uo2" "u233-uo2" "u234-uo2" ... ]` and `line:1810 column:1 - Validation Error: stdcomp children "wtpt" sum to 101 for 92000 group - instead of the required sum of 100`. The status bar at the bottom shows 'Line: 1810, Col: 1 /mavric/comps/stdcomp/name' and buttons for 'Validation' and 'Messages'.

# Fulcrum Plot Data

- Supports Most Major SCALE Data Formats
- Export to Image (supports svg)

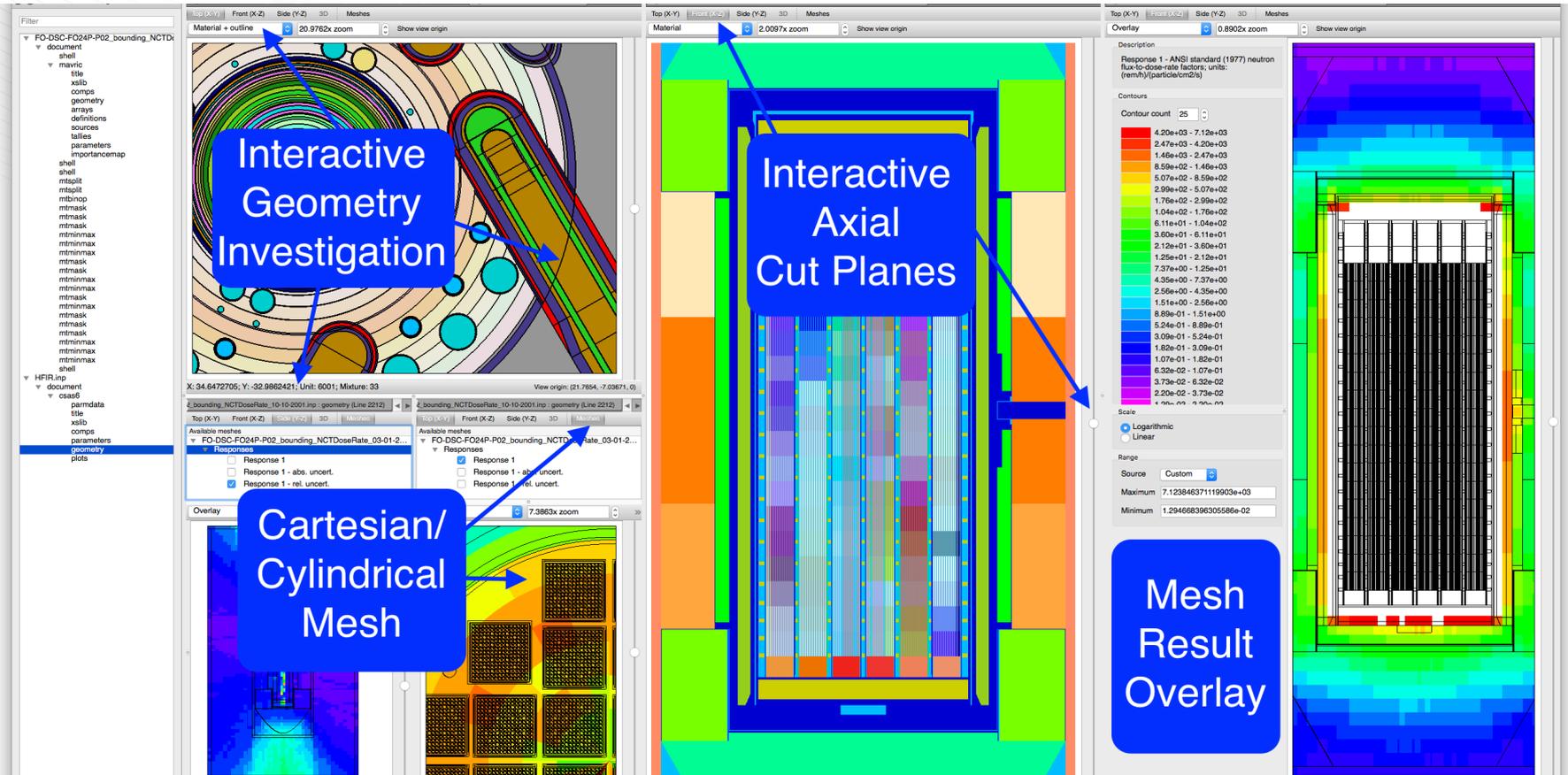


# Fulcrum General Output Result Plots



# Fulcrum Geometry Visualization

- Interactive Geometry Visualization
- Support for Most Mesh Data\*



\*Currently Support: 3dmap, Mesh Importance Map, Mesh Source Map, and Denovo Flux File

# Summary

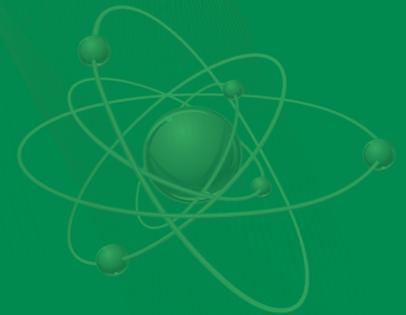
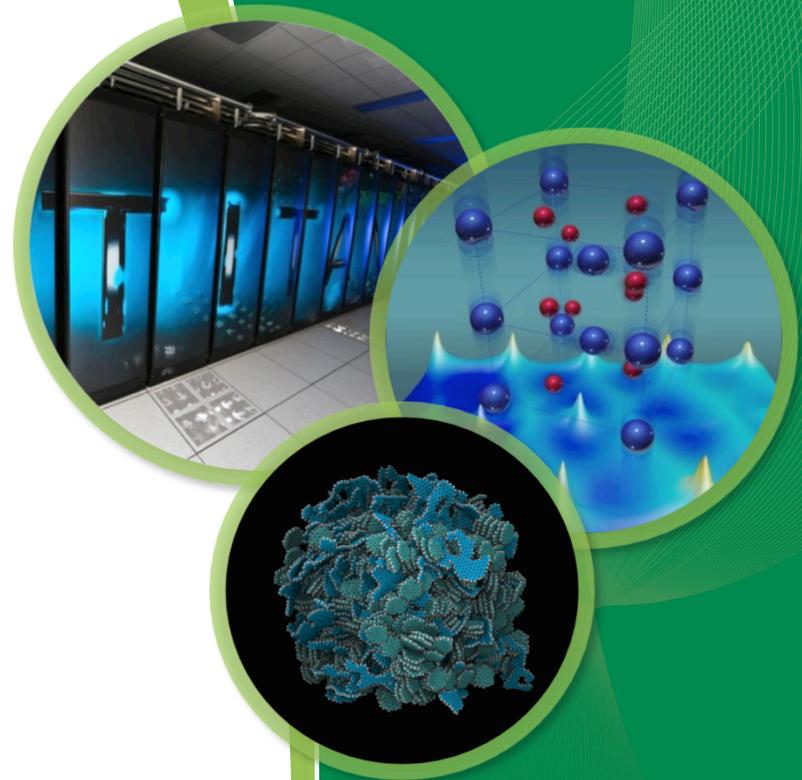
- Input editor facilitates problem creation, modification, navigation, validation, execution and output file viewing in a consistent, platform independent manner.
- Data plotting facilitates a fast, interactive means of interrogating input and output data.
  - Supports most SCALE data formats.
- Geometry viewer facilitates a fast, interactive means of interrogating SCALE Geometry.
  - Supports KENO and NEWT (non-polygon rendering).
- Fulcrum provides a modular workspace with splitting and drag-and-drop configurable layout.
- Questions?

# Fulcrum User Interface

## Input Editor Overview

Robert A. Lefebvre

October 2016



# Presentation Outline

- Fulcrum Input Editor Components
- Text Editor Settings
- Syntax Highlighting
- Document Quick Navigation
- Cursor Context
- Input Block Start and End Highlighting
- Input Autocompletion
- Input Validation
- Input Execution
- Output File Viewing
- Miscellaneous Features
- Future Features

# Fulcrum Input Editor Components

The image displays the Fulcrum Input Editor interface with several key components highlighted by blue callouts:

- Customizable Execution:** Located at the top of the editor window, showing menu options like 'Run', 'View...', and 'Edit...'.
- Document Quick Navigation:** A dropdown menu at the top left showing the current document name 'SCALE 6.2'.
- Context Aware Input Autocompletion:** A list of geometric shapes (cylinder, cone, etc.) with their respective parameters and units, appearing as the user types.
- Synchronized Input Text Editor:** The main text area where the user's input is displayed, showing a list of shapes and their parameters.
- Cursor Context:** A callout pointing to the current cursor position in the input text, showing the unit and region values.
- Execution Messages:** A window at the bottom right showing the output of the simulation, including the number of macros and the total number of meshes.
- Syntax Highlights:** A callout pointing to the highlighted text in the input, indicating the current block type (e.g., 'Sources Block').
- Input Block Highlights:** A callout pointing to the highlighted text in the input, indicating the current block type (e.g., 'Sources Block').
- Input Validation:** A callout pointing to the validation error message at the bottom left, indicating that a region value '30' does not exist in the set.

```
34 global unit 1
35 cylinder 1 8.255 25.40 -25.40
36 cylinder 2 10.795 27.94 -27.94
37 cylinder 3 20.955 27.94 -27.94
38 cylinder 4 13.335 40.64 30.48
39 cylinder 5 13.335 -30.48 -40.64
40 cylinder 6 35.56 45.72 -45.72
41
42 cone - kenovi (configurable) 2.4 -152.4
43 cone
44
45
46
47
48
49
50
51
52
53 end geom
54 dodecahedron - kenovi (configurable)
55 ellipsoid - kenovi (configurable)
56 'Defini
57 hexprism - kenovi (configurable)
58 read def
59 hopper - kenovi (configurable)
60 hopper
61 parallelepiped - kenovi (configurable)
62 end parallelepiped
63 pentagon - kenovi (configurable)
64 dist pentagon
65 plane - kenovi (configurable)
66 plane
67 xpplane
68 end ypplane
69 zpplane
70 grid
71 quadratic
72 rhexprism
73 rhomboid - kenovi (configurable)
74 rhomboid
75 ring - kenovi (configurable)
76 ring
77 sphere - kenovi (configurable)
78 sphere
79 end geometry
```

```
114 meshTally 1
115 photon
116 gridGeometryID=8
117 responseID=5
118 unit=1 region=7
119 energyBoundsID=1
120 end meshTally
121
122 multiplier=1000.0
123 end tallies
124
```

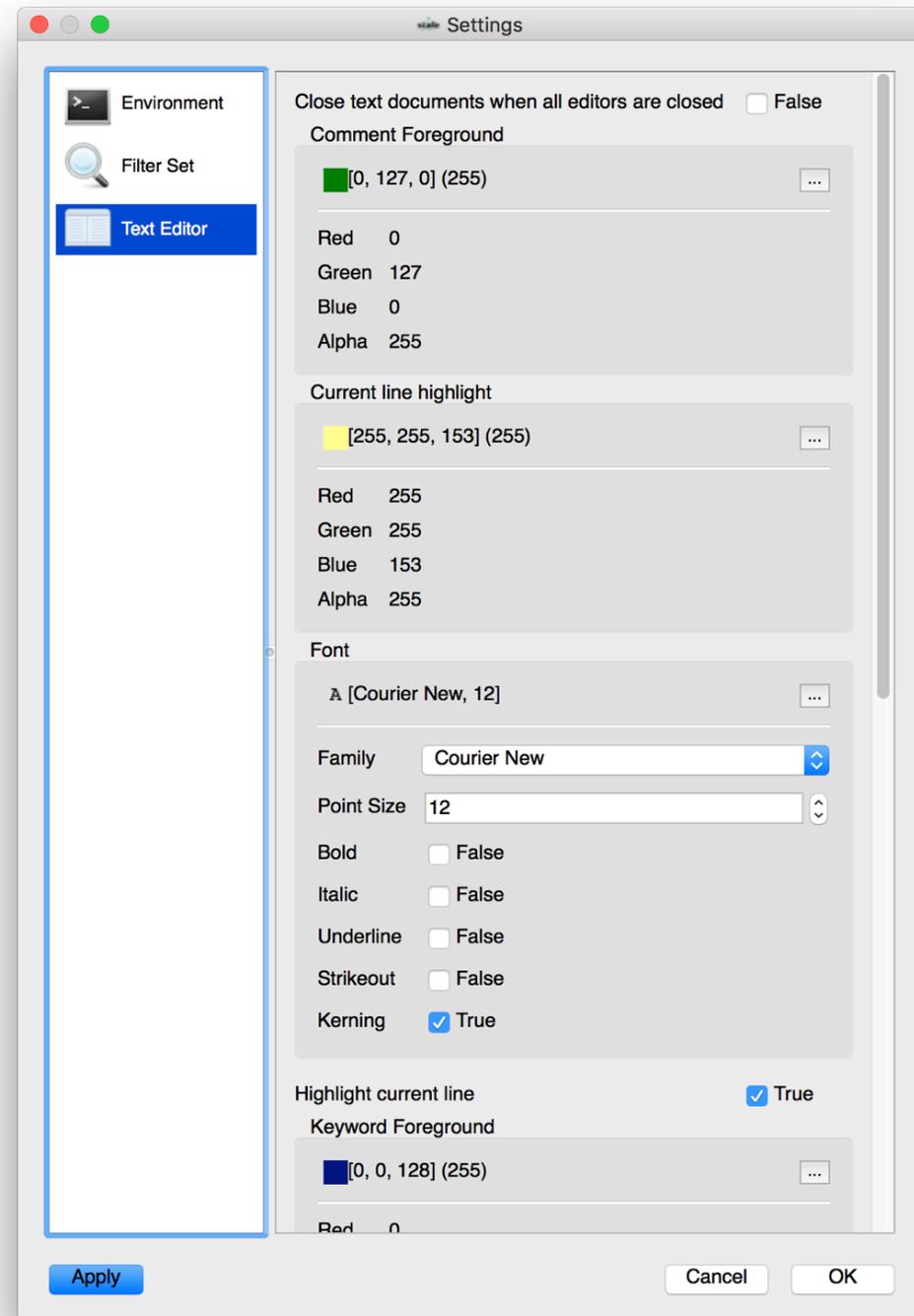
```
43
44
45
46 MAVRIC, part 2, writing the forward discrete ordinates input
47 *****
48
49 constructMacroMaterialRAYS (46 x-bins, 46 y-bins)
50
51 Total numMacros: 23
```

```
89 linear 30 0.00e6 1.50e6
90 bounds 0.510e+6 0.512e+6 1.172e6 1.174e6 1.331e6 1.333e6 end
91 end energyBounds
92 end definitions
93
94 'Sources Block
95
96
97 read sources
98 src 1
99 title="one of cobalt-60"
100 useNormConst
101 multiplier=37e9
102 cylinder 8.255 25.40 -25.40
103 photons
104 eDistributionID=1
105 end src
106 end sources
107
108 'Tallies Block
109
110 ' only collect mesh tally information outside the package (in air region)
111 ' multiplier converts responses from rem/hr to mrem/hr
112
113 read tallies
114 meshTally 1
115 photon
116 gridGeometryID=8
117 responseID=5
118 unit=1 region=7
119 energyBoundsID=1
```

Validation Error: region value "30" does not exist in set: [../././cone/id  
.././cuboid/id  
.././cylinder/id  
.././dodecahedron/id  
.././ellipsoid/id  
.././hexprism/id  
.././hopper/id  
.././parallelepiped/id  
.././pentagon/id  
.././plane/id  
.././quadratic/id  
.././rhexprism/id  
.././rhomboid/id  
.././ring/id  
.././sphere/id  
.././wedge/id  
.././xcylinder/id

# Text Editor Settings

- Change font attributes
- Change syntax color by category
- Change current line highlight
- Modify recognized input file extensions
  - Add a '.i' extension
- Update default input editor close behavior
  - When closing a tab, should the document also be closed if the closed tab is the last document tab.
- Accessed via File>Settings



# Syntax Highlights

SCALE

File Edit View Run Help

Reload Save Save as Close tab Print Cut Copy Paste Undo Redo Find

mavric.aos100.inp

document SCALE 6.2 Run View... Edit...

```
9 *****
10 ' Simplified model of the AOS-100
11 '
12 ' Alpha Omega Services Inc (AOS)
13 ' International Isotopes Inc. of Idaho Falls, Idaho is the exclusive worldwide
14 ' distributor of the AOS Ra... tem
15 *****
16
17 =mavric
18 AOS-100: Demonstrate use of ... transport
19 v7-200n47g
20
21
22 ' Composition Block - standard SCALE input
23 -----
24 read composition
25   ss304           1   end
26   wptTungsten    2  17.8 4   74182 26 74183 14 74184 31 74186 29 end
27   dry-air        3   end
28 end composition
29
30 -----
31 ' Geometry Block - SCALE standard geometry package (SGGP)
32 -----
33 read geometry
34   global unit 1
35     cylinder 1  8.255  25.40 -25.40
36     cylinder 2 10.795  27.94 -27.94
37     cylinder 3 20.955  27.94 -27.94
38     cylinder 4 13.335  40.64  30.48
39     cylinder 5 13.335 -30.48 -40.64
40     cylinder 6 35.56   45.72 -45.72
41
42     cuboid 99 139.7 -139.7 139.7 -139.7 152.4 -152.4
43
44     media 3 1 1
45     media 1 1 2 -1
46     media 2 1 3 -2
47     media 2 1 4
48     media 2 1 5
49     media 1 1 6 -3 -4 -5
50
51     media 3 1 99 -6
52   boundary 99
53 end geometry
54
55 -----
56 ' Definitions Block
57 -----
58 read definitions
59   response 5
60     title="ANSI standard (1977) neutro...s"
61     doseData=9504
62   end response
63
64   distribution 1
65     title="cobalt-60 gammas/decay"
66     discrete 347140 826100 1173228 1332492 2158570 2505692 end
67     truepdf 0.000075 0.000076 0.9985 0.999826 0.000012 0.00000002 end
68   end distribution
69
70   gridGeometry 7
71     title="mesh for discrete ordinates/importance map/biased source"
```

Sequence Declarator  
Foreground

Number  
Foreground

Keyword  
Foreground

mavric.aos100.inp

document SCALE 6.2 Run View... Edit...

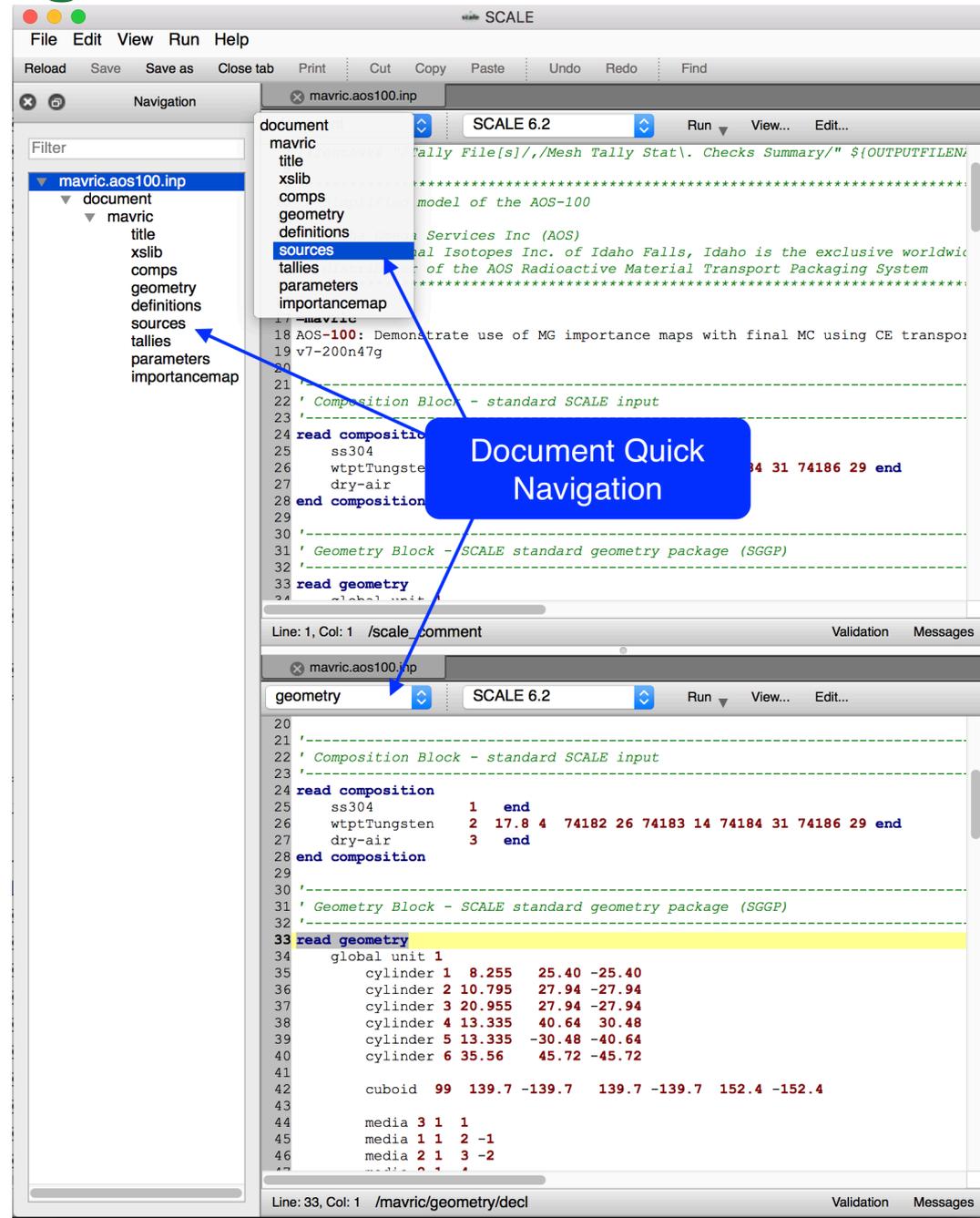
```
53 end geometry
54
55 -----
56 ' Definitions Block
57 -----
58 read definitions
59   response 5
60     title="ANSI standard (1977) neutro...s"
61     doseData=9504
62   end response
63
64   distribution 1
65     title="cobalt-60 gammas/decay"
66     discrete 347140 826100 1173228 1332492 2158570 2505692 end
67     truepdf 0.000075 0.000076 0.9985 0.999826 0.000012 0.00000002 end
68   end distribution
69
70   gridGeometry 7
71     title="mesh for discrete ordinates/importance map/biased source"
72     xLinear 28 -35.56 35.56
73     yLinear 28 -35.56 35.56
74     zLinear 36 -45.72 45.72
75
76     xLinear 22 -139.7 139.7
77     yLinear 22 -139.7 139.7
78     zLinear 24 -152.4 152.4
79   end gridGeometry
80
81   gridGeometry 8
82     title="mesh for mesh tally - 1 inch voxels"
83     xLinear 110 -139.7 139.7
84     yLinear 110 -139.7 139.7
85     zLinear 120 -152.4 152.4
86   end gridGeometry
87
88   energyBounds 1
89     linear 30 0.00e6 1.50e6
90     bounds 0.510e+6 0.512e+6 1.172e6 1.174e6 1.331e6 1.333e6 end
91   end energyBounds
92 end definitions
93
94 -----
95 ' Sources Block
96 -----
97 read sources
98   src 1
99     title="one Ci of cobalt-60"
100    useNormConst
101    multiplier=37e9
102    cylinder 8.255 25.40 -25.40
103    photons
104    eDistributionID=1
105  end src
106 end sources
107
108 -----
109 ' Tallies Block
110 ' only collect mesh tally information outside the package (in air region)
111 ' multiplier converts responses from rem/hr to mrem/hr
112 -----
113 read tallies
114   meshTally 1
115     photon
```

String  
Foreground

Comment  
Foreground

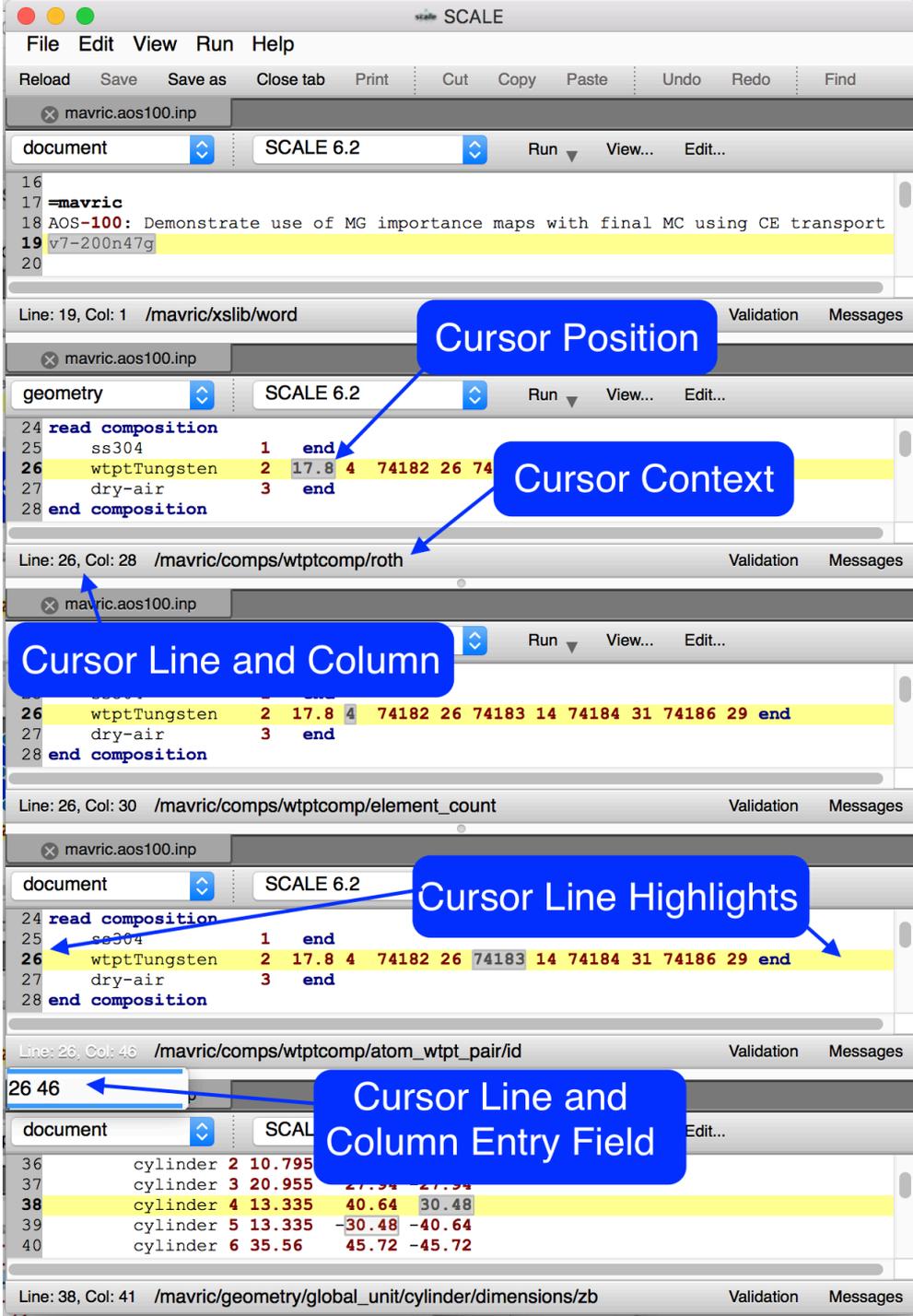
# Document Quick Navigation

- Provides document outline.
- Quickly navigate to section from input editor drop-down or navigation tree.
- Places text cursor at start of input block.



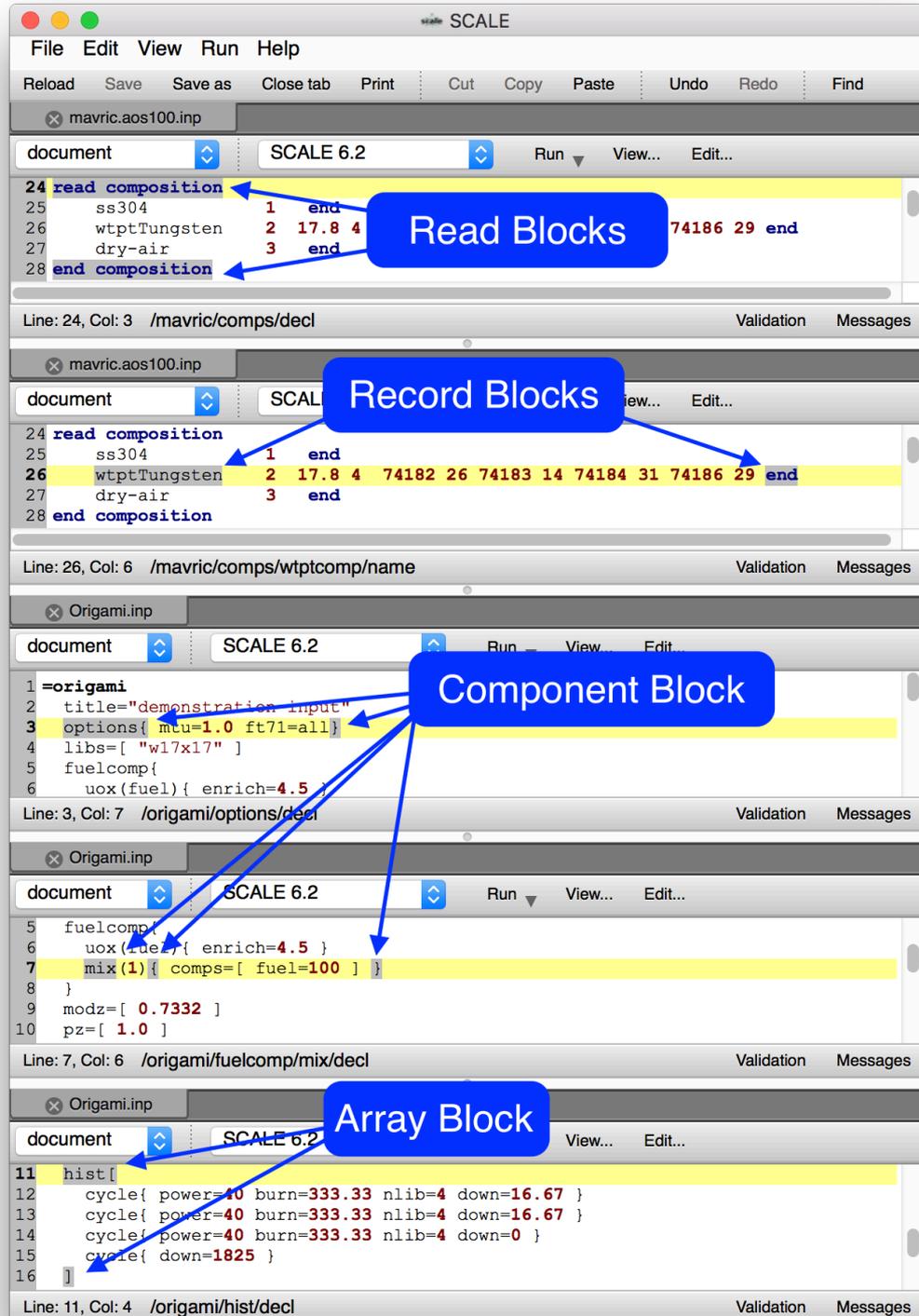
# Cursor Context

- Fulcrum uses cursor position to determine cursor context, line, column, and highlighting.
- Cursor context provides a file directory-style listing of the input component at cursor position.
  - Helpful for identifying position-dependent input components.
  - Helpful for advanced SCALE features like Sampler model perturbations.
- Cursor line highlights provide fast cursor acquisition via bold-faced line number and highlighted line visual indicators.
- Cursor line and column entry fields provide quick navigation
  - Useful for entering line and column numbers included in job execution failure messages.
  - Accessible via clicking Line, Col text.



# Input Block Start and End Highlighting

- Helps new users identify sections of input.
- Re-enforces SCALE's Read Block construct.
- More effectively communicates Record Blocks which could have user-specified beginning.
- Assists users in identifying new input component sections, such as the Component and Array Blocks used in Origen and Origen input.



# Input Autocompletion Overview

Input Autocompletion provides the user a jump start in input creation and editing. Autocompletion uses the cursor's context within the input to determine what input components are available and can be inserted. The types of autocompletion are as follows:

- Static input component insertion.
  - Inserts a boilerplate piece of input requiring the user to update fields with appropriate values.
  - Provides complete component incorporating component order, etc.
- Configurable input component insertion.
  - Uses a popup window to capture component values and substitutes these values into a template creating and inserting a complete piece of input (potentially an entire input).
- Input value substitution. Uses cursor context to provide a list of legal attribute values.
  - Convenient for selecting parameter values from a list (htm=yes or no).
  - Helpful for substituting identifiers needed from other input components (available mixtures, region ids etc).

# Input Autocompletion : Static Text

Access Autocomplete via  
\* CTRL+SPACE Keys, or,  
\* Edit...>Autocomplete

- Inserts default values. Requires user to update values as needed.

The screenshot shows the SCALE software interface with a menu open for the 'cylinder' command. The menu lists various options like 'cone', 'cuboid', 'cylinder', 'xcylinder', etc. The 'cylinder' option is highlighted in blue. The main text area shows the input '2.4 -152.4' for the 'cylinder' command. The status bar at the bottom indicates 'Line: 40, Col: 9 /mavric/geometry/global\_unit'.



The screenshot shows the SCALE software interface after the autocompletion. The 'cylinder' command is now fully entered as 'cylinder 99 139.7 -139.7 139.7 -139.7 152.4 -152.4'. A blue callout box with a white border points to the input, containing the text 'Default Id, Radius, Ztop and Zbottom Inserted'. The status bar at the bottom indicates 'Line: 41, Col: 1 /mavric/geometry/global\_unit'.

# Input Autocompletion : Static Text

- Static text insertion allows new and experienced users to quickly select and generate input that has order dependent components
  - Standard Composition Records require a sequence of unlabeled components (mixture, volume fraction, temperature, etc).
  - The requirement for the user to recall the correct order of entry is significantly reduced.
- Cursor context facilitates the user in identifying the inserted components needing to be changed.
  - Greatly assists the user in the worst of order-dependent, unlabeled input entry.

Access Autocomplete via  
 \* CTRL+SPACE Keys, or,  
 \* Edit...>Autocomplete

The screenshot shows the SCALE software interface with a text editor window open to a file named 'mavric.aos100.inp'. The editor displays a series of comments and a 'read composition' block. An autocomplete menu is overlaid on the 'read composition' block, listing various options for the 'stdcomp' field. The menu items include 'basic (configurable)', 'basic', 'basic + volume fraction', 'basic + volume fraction + temperature', 'basic + volume fraction + temperature + isotopics', 'basic + atomic density (configurable)', 'basic + atomic density', 'basic + atomic density + temperature', 'basic (configurable)', 'basic + volume fraction', 'basic + volume fraction + temperature', 'basic + volume fraction + temperature + isotopics', 'rho + density + temperature + volume fraction', 'molar + density + temperature + volume fraction', 'massfrac + density + temperature + volume fraction', 'molefrac + density + temperature + volume fraction', and 'molality + density + temperature + volume fraction'. The 'basic + volume fraction + temperature + isotopics' option is currently selected. The status bar at the bottom indicates 'Line: 26, Col: 5'.

Order Dependent  
 Static Input  
 Enumerations

# Input Autocompletion : Static Text

- Static text autocompetition also facilitates abbreviated input to include the component's description allowing users to discover and/or more quickly recall the necessary input components for their analysis.
- Cursor context allows the autocompletion popup to show what is legal and has not already been specified.

Access Autocomplete via  
\* CTRL+SPACE Keys, or,  
\* Edit...>Autocomplete

The screenshot shows the SCALE 6.2 software interface. The main window displays a text file named 'csas6\_7.inp' with a list of parameters for a simulation. The parameters are listed in a table-like format with columns for item number, name, and various numerical values. An autocompletion popup is visible over the 'gen' parameter on line 43, listing various options with their descriptions. The popup is blue and contains the following text:

rnd	- random number
tme	- execution time (min)
tba	- batch time (min)
wta	- average weight
wth	- wt. for splitting
wtl	- russian roulette wt.
sig	- deviation limit
msh	- size of flux mesh
tcl	- ce temperature tol.
dbh	- upper dbrc energy cutoff
dbl	- lower dbrc energy cutoff
gen	- no. of generations
ngp	- no. per generation
nsk	- generations skipped
res	- gens. between restart
nbk	- neutron bank positions
xnb	- extra bank entries
nfb	- fission bank positions
xfb	- extra bank entries
xld	- no. of extra l-dâs
beg	- restart at this gen.
nb8	- blocks for d.a. unit
nl8	- length of d.a. block
nqd	- quadrature order for angular fluxes moments
ngp	- number of energy groups for tallying
pnm	- order of flux moments
cxm	- reaction rate tallying mode
cep	- continuous energy directory file
fno	- output restart file identifier
fni	- input restart file identifier
dbr	- use dbrc for scattering
dbx	- doppler broadening method
app	- append restart data
flx	- collect and print
fdn	- fission densities
adj	- adjoint calculation
ptb	- use probability tables

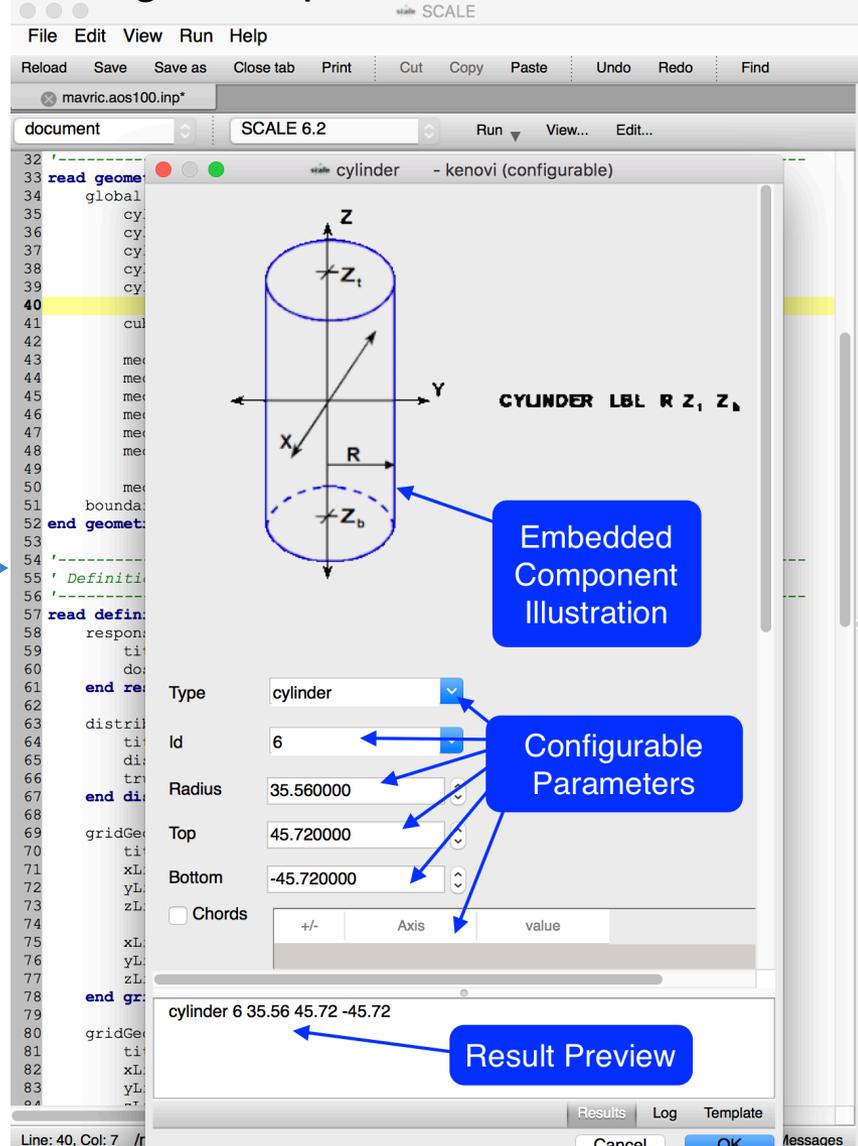
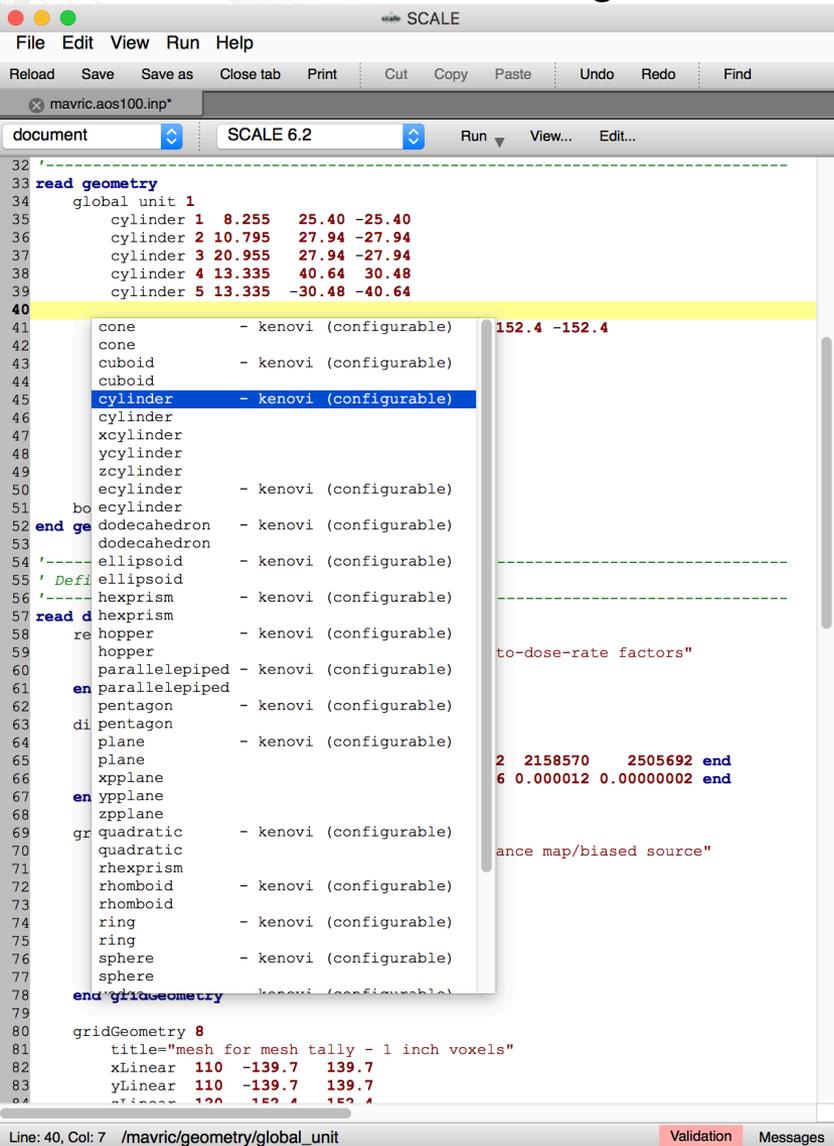
The status bar at the bottom of the window shows 'Line: 31, Col: 19 / csas6/parameters' and 'Validation Messages'.

Parameters  
with descriptions

# Input Autocompletion : Configurable Text

Access Autocomplete via  
\* CTRL+SPACE Keys, or,  
\* Edit...>Autocomplete

- Allows user to configure values prior to inserting into input.



# Input Autocompletion : Configurable Text

- Configurable autocompletion allows entire input creation.
- Results preview facilitates learning input syntax.
- Attributes can be labeled even when the actual input attribute may not have a label.
- Attributes can have a drop-down listing the available or common values to specify.

Access Autocomplete via  
\* CTRL+SPACE Keys, or,  
\* Edit...>Autocomplete

The screenshot shows the SCALE software interface. At the top, there is a menu bar with 'File', 'Edit', 'View', 'Run', and 'Help'. Below the menu bar, there are buttons for 'Reload', 'Save', 'Save as', 'Close tab', 'Print', 'Cut', 'Copy', 'Paste', and 'Undo'. The main window title is 'NewProblem.inp' and the version is 'SCALE 6.2'. The interface displays a configuration window for 'origami' with the following parameters:

Parameter	Value
Title	this-is-my-title
Fuel Type	w17x17
Uranium (MTU)	1.0
Enrichment (Wt%U235)	4.5
Burnup (MWd/MTU)	40000
Cycles	3
Number of Burnup Interpolations per Cycle	4
Cooling Time (days)	1825
Power History - Percent Up	95
Power History - Average Power (MW/MTU)	40
Moderator Density (g/cc)	0.7332

A blue callout box labeled 'Results Preview' points to a window showing the generated XML configuration for 'origami':

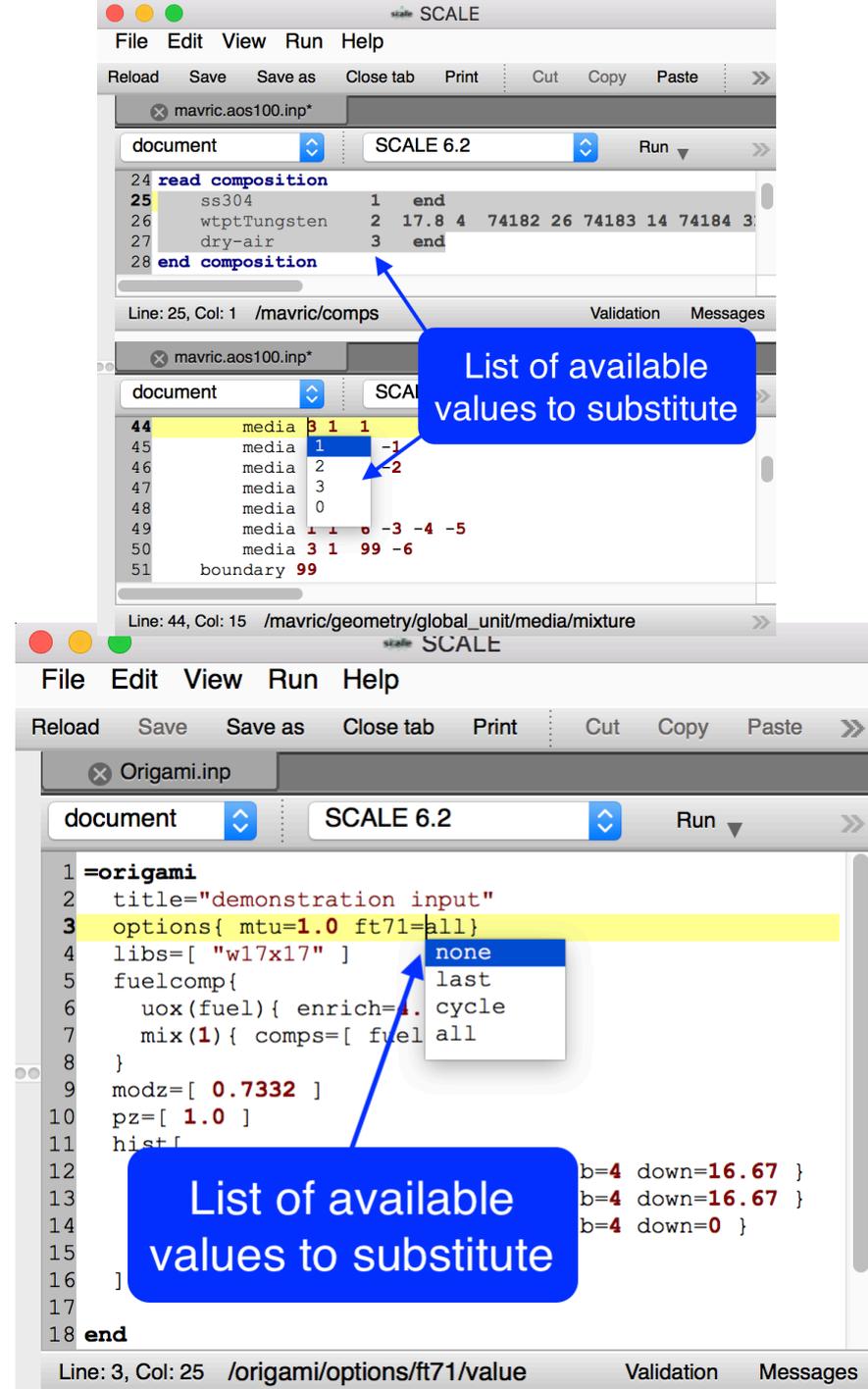
```
=origami
title="this-is-my-title"
options{ mtu=1.0 ft71=all}
libs=["w17x17"]
fuelcomp{
  uox(fuel){ enrich=4.5 }
  mix(1){ comps=[ fuel=100 ] }
}
modz=[ 0.7332 ]
pz=[ 1.0 ]
hist{
  cycle{ power=40 burn=333.33 nlib=4 down=16.67 }
  cycle{ power=40 burn=333.33 nlib=4 down=16.67 }
  cycle{ power=40 burn=333.33 nlib=4 down=0 }
  cycle{ down=1825 }
}
end
```

At the bottom of the interface, there are buttons for 'Results', 'Log', and 'Template', and a 'Cancel' button next to an 'OK' button. The status bar at the bottom indicates 'Line: 1, Col: 1' and 'Validation Messages'.

# Input Autocompletion : Value Substitution

- When autocompletion is requested on an existing value that is either a member of a set of predefined or existing input component values/identifiers, an autocomplete popup is presented listing the available values to substitute.
- Helps user quickly remember/learn what is legal/available.

Access Autocomplete via  
\* CTRL+SPACE Keys, or,  
\* Edit...>Autocomplete



# Input Validation Overview

- SCALE validation messages consist of parse and validation errors along with the input line and column.
  - Clicking the message will quick navigate to the location in the input editor
- SCALE parse errors prevent the further processing of input and are hard errors in that the interpretation of the input is incomplete.
  - Parse errors typically involve the input that guides the input parser. E.g., number of element-weight-percent pairs not matching actual number provided in the input.
- SCALE validation uses over 20 rules to provide immediate validation. These include value ranges, value uniqueness – is it unique in an input context, value existence – does the value exist in an input context, value enumeration – is the value a member of a list of values.

# Input Validation Overview

- Parse errors cascade into other parse errors as the input parser attempts to find legitimate input.
- Parse errors often cause the input parser to terminate early preventing the entire input from being validated.
  - Example below has wtpt element count (line 27) specified as 3, but only has 2 (8000,7000) specified causing a parse error and cascade.

The image displays two screenshots of the SCALE software interface, illustrating the impact of a parse error on validation.

**Top Screenshot:** Shows the input file `mavric.aos100.inp` with the following content:

```
23 '-----  
24 read composition  
25   ss304           1   end  
26   wtptTungsten   2 17.8 4 74182 26 |74183 14 74184 41 74186 29 end  
27   wtptdry-air    3 0.0012 3 8000 23.5 7000 76.5081 end  
28 end composition
```

The error messages displayed are:

- line:27 column:55 - Parse Error: expected composition nuclide id, found 'end'
- line:28 column:1 - Parse Error: expected sequence terminator, found 'end composition'
- line:17 column:1 - Validation Error: mavric has 0 "geometry" occurrences - when there should be a minimum occurrence of 1
- line:17 column:1 - Validation Error: mavric has 0 "sources" occurrences - when there should be a minimum occurrence of 1
- line:26 column:5 - Validation Error: wtptcomp children "wtpt" sum to 110 - instead of the required sum of 100

The status bar shows: Line: 26, Col: 41 / /mavric/comps/wtptcomp/atom\_wtpt\_pair/id

**Bottom Screenshot:** Shows the same input file, but the cursor is positioned at the end of line 28:

```
23 '-----  
24 read composition  
25   ss304           1   end  
26   wtptTungsten   2 17.8 4 741  
27   wtptdry-air    3 0.0012 3 800  
28 end composition
```

The status bar shows: Line: 28, Col: 16 / /

Annotations in blue boxes:

- Parse vs validation errors:** Points to the parse error messages in the top screenshot.
- No cursor context after parse error or document quick navigation due to parse error:** Points to the cursor position in the bottom screenshot, indicating that the parser has terminated early, preventing the rest of the input from being validated and the cursor from moving to the end of the document.

# Input Validation : Required Input

- Required input should minimally occur once in the input.
- When required input is missing autocompletion can quickly generate the missing blocks.

The screenshot shows the SCALE software interface. The main window displays a code editor with the following content:

```
1 =mavric
2 Demonstration input
3 v7-200n47g
4 read comp
5 ' TODO: define comp
6 end comp
7
8 ' TODO: define geometry
9
10 ' TODO: define sources
11
```

A blue callout box labeled "Require input missing" points to lines 5, 8, 10, and 11. The error message at the bottom of the window reads:

```
line:1 column:1 - Validation Error: mavric has 0 "geometry" occurrences - when there should be a minimum occurrence of 1
line:1 column:1 - Validation Error: mavric has 0 "sources" occurrences - when there should be a minimum occurrence of 1
line:4 column:1 - Validation Error: comps has zero of: [ stdcomp wptcomp atomcomp arbmcomp soln solution ] - at least one must occur
```

The status bar at the bottom indicates the current position: "Line: 4, Col: 1 /mavric/comps/decl".

# Input Validation : Value Errors

Value constraint errors can be hard to find. Input validation provides immediate feedback on the following.

- Simple value ranges
  - E.g.,  $0.0 < x \leq 100$
- More complex
  - Expected value sums
  - Expected value function (increasing, decreasing, etc.)
  - Component relationship
    - E.g.,  $X > Y$

The image displays three screenshots of the SCALE software interface, illustrating input validation errors. Each screenshot shows a code editor window with a file named 'mavric.aos100.inp' and a 'Validation' pane at the bottom.

**Top Screenshot:** Shows a code block for 'wtptcomp' with the following data:

Component	Weight	Sum
ss304	1	end
wtptTungsten	2	17.8 4 74182 26 74183 14 74184 31.5 74186 29 end
dry-air	3	end

Validation messages:

- line:26 column:5 - Validation Error: wtptcomp children "wtpt" sum to 100.5 - instead of the required sum of 100
- line:30 column:1 - Validation Error: multiregion children "radius" are not strictly increasing at line:31 column:30
- line:40 column:35 - Validation Error: zb value "27.94" is greater than or equal to the allowed maximum exclusive value of "27.94" from "../zt"

**Callout:** Incorrect weight-percent sum

**Bottom Screenshot:** Shows a code block for 'multiregion' with the following data:

Zone	Radius
1	8.255 2 20.955 3 13.335 end zone

Validation messages:

- line:26 column:5 - Validation Error: wtptcomp children "wtpt" sum to 100.5 - instead of the required sum of 100
- line:30 column:1 - Validation Error: multiregion children "radius" are not strictly increasing at line:31 column:30
- line:40 column:35 - Validation Error: zb value "27.94" is greater than or equal to the allowed maximum exclusive value of "27.94" from "../zt"

**Callout:** Zone radii overlap - validation message indicates the input block and offending component

**Bottom Screenshot:** Shows a code block for 'cylinder' with the following data:

Cylinder	zt	zb
1	8.255	25.40 -25.40
2	10.795	27.94 27.94
3	20.955	27.94 -27.94
4	13.335	40.64 30.48
5	13.335	30.48 40.64

Validation messages:

- line:26 column:5 - Validation Error: wtptcomp children "wtpt" sum to 100.5 - instead of the required sum of 100
- line:30 column:1 - Validation Error: multiregion children "radius" are not strictly increasing at line:31 column:30
- line:40 column:35 - Validation Error: zb value "27.94" is greater than or equal to the allowed maximum exclusive value of "27.94" from "../zt"

**Callout:** Relationship between 2 components (zt and zb) violated

# Input Validation : Reference Errors

Using component identifiers can lead to duplicate or missing identifiers.

- Checks if the component's identifier is unique in the required input contexts.
  - Ensure all geometry regions have unique identifiers.
- Check if the component identifier references an existing component

Identifier is duplicate - both input locations are provided.

Region (cone, cuboid, etc.) with given id (99) does not exist in the specified input.

Missing component search paths.

# Input Execution Overview

- Execution is preconfigured to execute the SCALE included with Fulcrum.
- Execution of other applications (e.g., prior SCALE release) can be setup.
- Only local execution (no cluster or queue support, yet).
- Execution can be in the background.
  - Allows closing Fulcrum without cancelling/terminating the execution.
- Input listing, mixing table, alias expansion, and volume calculation [prototype] are available via quick execution buttons.
- Messages from executions are stored in time stamped tabs.

# Input Execution : Customized Configurations

- Add new
- Clone existing
- Remove existing
- Modify existing
- Show executable help
- Provide additional arguments

The image displays the SCALE application interface. The main window, titled 'SCALE', has a menu bar with 'File', 'Edit', 'View', 'Run', and 'Help'. Below the menu bar are buttons for 'Reload', 'Save', 'Save as', 'Close tab', 'Print', 'Cut', 'Copy', 'Paste', 'Undo', 'Redo', and 'Find'. A toolbar shows a document icon, a dropdown menu with 'SCALE 6.2' selected and 'Customize...' visible, and buttons for 'Run', 'View...', and 'Edit...'. A tab labeled 'mavric.aos100.inp' is open. A 'Configurations' dialog box is open, showing a list of configurations with 'SCALE 6.2' selected. Below the list are 'Add', 'Clone', and 'Remove' buttons. The 'Properties' section shows fields for 'name' (SCALE 6.2), 'executable' (/Applications/SCALE-6.2.1.app/Contents/Resources/bin/scalerte), and 'arguments' ('-m'). 'Help' and 'Apply' buttons are at the bottom left, and 'Cancel' and 'OK' buttons are at the bottom right. A 'scalerte help' window is open, displaying the following text:

```
2 Usage: scalerte <options> inputfile(s)
3 Where options are:
4 -a: Specify alias file.
5   -a path/to/aliasesfile
6 -c: Return centrm output to filename.centrmfiles directory.
7 -f: Add hostname to output filename.
8 -h: Print this help message
9 -I: Number of threads to use for MPI/OpenMP directives. -I 4.
10 -m: Turn messages on
11 -M: Specify a machine names file for SCALE parallel capabilities.
12   -M /path/to/machine/names/file
13 -n: Nice level, ignored on windows. -n 2
14 -N: Number of MPI processes to run. -N 20.(ONLY AVAILABLE WITH MPI BUILT SCALE)
15 -o: Overrides the default 'inputfile.out' output name.
16   -o path/to/outputfile.
17 NOTE: If the path/to/outputfile already exists, it will be deleted.
18       If the option is specified while in stack mode (multiple input files)
19       the value provided is prepended to the inputfile's basename.
```

A blue callout box labeled 'Help Information' has an arrow pointing to the 'Help' button in the 'Configurations' dialog box.

# Input Execution : Running Jobs

- Run launches the selected configuration (SCALE 6.2).
- For Run a time-stamped Messages Tab is added with application messages panel.
- Alternatives are conveniently available via the Run drop-down.
  - Run in background launches the job but with a terminal instead of a messages tab.
  - Expand aliases unrolls aliased input (TRITON).
  - Input listing provides directory-like input listing useful for Sampler model perturbation.
  - Mixing table lists the atomic number densities (atoms/b-cm) per nuclide per mixture.
  - Calculate volumes (prototype) runs a user-specified number of rays per geometry axis and accumulates media volumes. The complete input with media 'vol' cards is echoed in the message tab.

The screenshot displays the SCALE 6.2 software interface. At the top, the menu bar includes File, Edit, View, Run, and Help. Below the menu bar, there are options for Reload, Save, Save as, Close tab, Print, Cut, Copy, Paste, Undo, Redo, and Find. The main window shows a document titled 'SCALE 6.2' with a 'Run' button. A blue callout box points to the 'Run' button and the 'SCALE 6.2' dropdown, stating 'Selected execution configuration when Run invoked'. Below the document, there are several message tabs, each with a timestamp. A blue callout box points to one of these tabs, stating 'Message Tab per Run invocation'. The selected message tab shows the following text:

```
158 Starting the Monte Carlo game with 00003ECD7B4B4E8B
159
160 -----
161
162 batch  batches  batch time  elapsed time  next randomSeed
163
164
165 4F916B6118236464
```

Below the message tabs, there is a 'Run' dropdown menu with several options. A blue callout box points to this menu, stating 'Convenient Run Alternatives'. The options in the dropdown are:

- Run in background
- Expand aliases (⌘A)
- Input listing (⌘L)
- Mixing table (⌘M)
- Calculate volumes

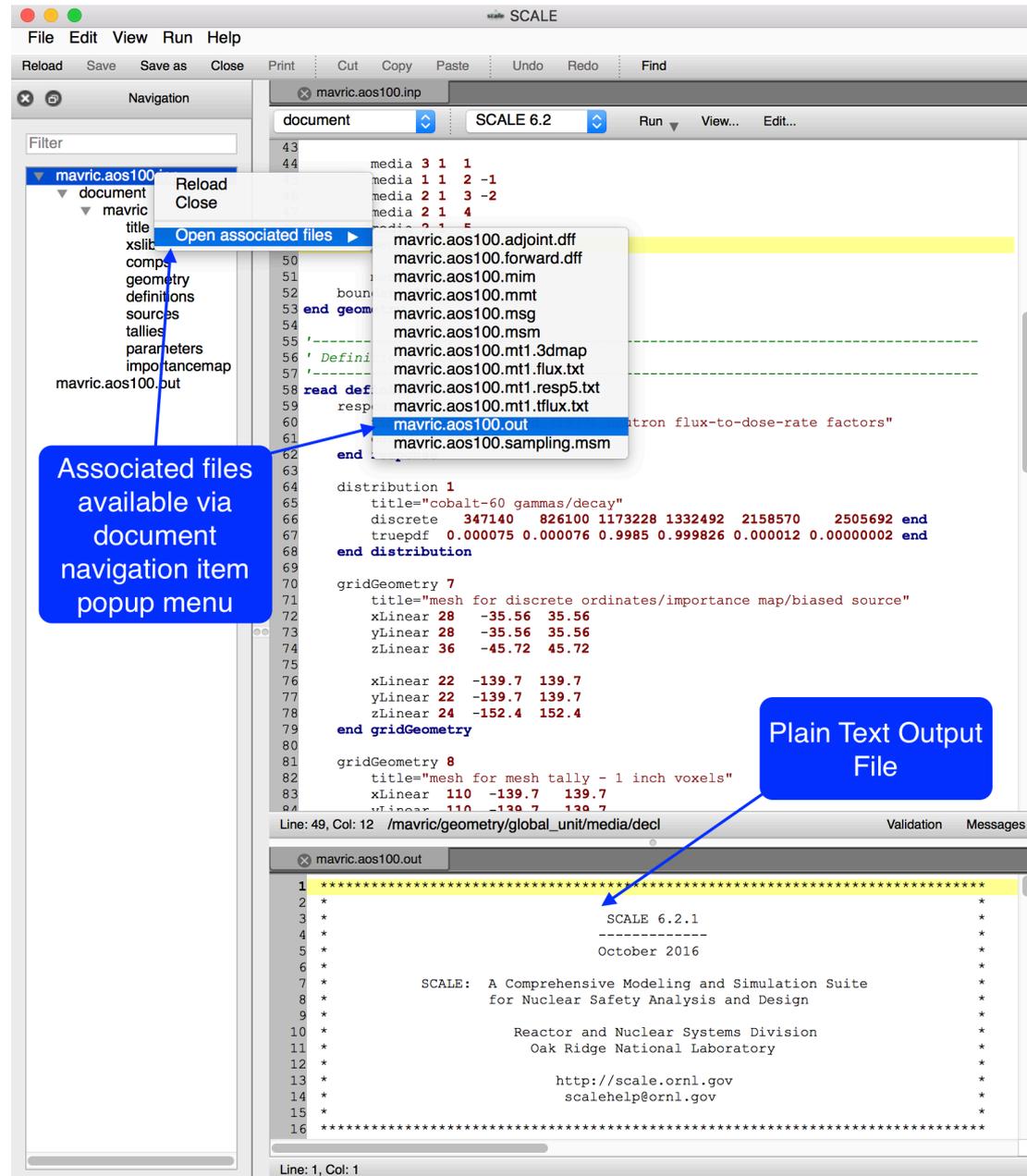
Below the dropdown menu, there is a table showing the results of a calculation. The table has the following columns: Entry, Mixture, Nuclide, Density (atoms/b-cm), and Temperature (K). The table contains 20 rows of data, with the first row being a header row.

Entry	Mixture	Nuclide	Density (atoms/b-cm)	Temperature (K)
6	Mixture = 1 with density(g/cc) = 7.9400 and temperature(K) = 293.00			
7				
8				
9	1	6012	3.150793e-04	
10	2	6013	3.407812e-06	
11	3	14028	1.570105e-03	
12	4	14029	7.976252e-05	
13	5	14030	5.264157e-05	
14	6	15031	6.946885e-05	
15	7	24050	7.591783e-04	
16	8	24052	1.464000e-02	
17	9	24053	1.660058e-03	
18	10	24054	4.132236e-04	
19	11	25055	1.740717e-03	
20	12	26054	3.421905e-03	
21	13	26056	5.371659e-02	
22	14	26057	1.240550e-03	
23	15	26058	1.650942e-04	
24	16	28058	5.268730e-03	
25	17	28060	2.029506e-03	
26	18	28061	8.822118e-05	
27	19	28062	2.812878e-04	
28	20	28064	7.163575e-05	
29				
30	Mixture = 2 with density(g/cc) = 17.8000 and temperature(K) = 293.00			

At the bottom of the screenshot, the status bar shows 'Line: 38, Col: 41 /mavric/geometry/global\_unit/cylinder/dimensions/zb' and 'Validation Messages'.

# Output File Viewing

- Easy to access from the Input file's list of associated files popup context menu.
- No intelligent outline, yet.
- Output file Can be drag-n-dropped onto Fulcrum from a file browser (as can any SCALE file with an extension, \*.inp, \*.out, etc.).



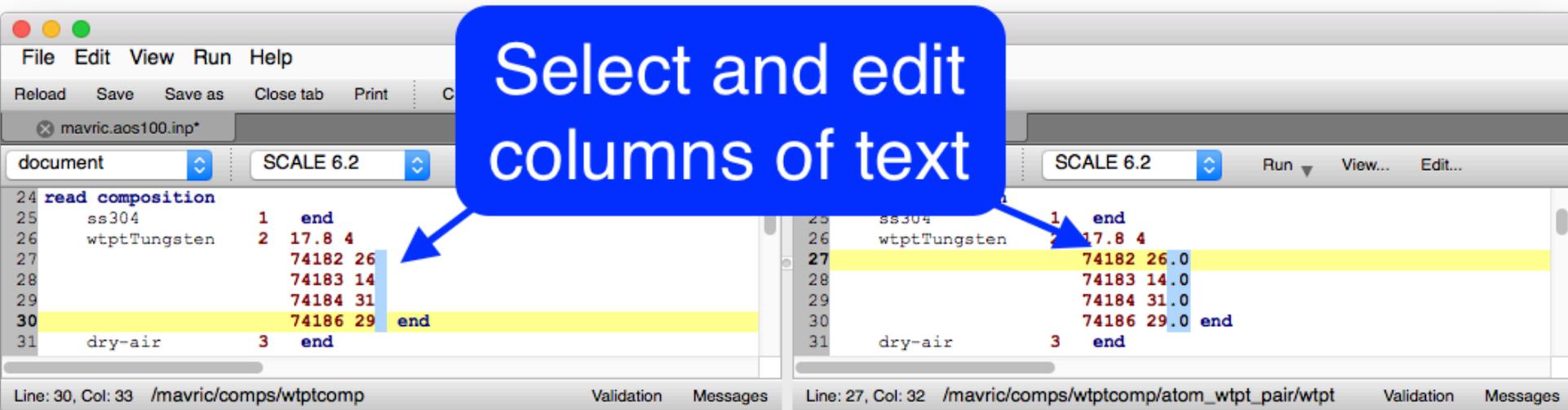
# Miscellaneous Features

- Column select/edit
  - via ALT+left click+mouse drag key and mouse combo
- Go to definition – allows quick navigation to input components definition via a right click popup context menu.
  - E.g., anywhere an identifier is used to reference another input component.
- Math evaluator
  - Ability to evaluate selected text as a math expression – replaces selection with expression's result.
- Comment toggle
  - Ability to comment/uncomment selected lines
- Indent/unindent
  - Ability to indent/unindent selected lines
- Auto saves – automatic back up to *inputname.fulcrum.autosave*.
  - File exists only while there are unsaved document changes
- Features illustrated on following slides

# Miscellaneous : Column Selection/Edit

Formatting related text into aligned columns allows for faster recognition and column-wise text operations.

- Fulcrum provides column selection via ALT+MOUSE SELECTION.
- With column selection made, any edits are made to all columns for each row.
  - E.g., Update all isotope weight percent values to have a decimal digit.



# Miscellaneous : Go To Definition

The 'Go To Definition' feature (available via right clicking an input component) is intended to facilitate the user in quickly navigating to the component being referencing. New users can discover input component relationships. Experienced users can have their navigation accelerated, especially in larger inputs.

- Referenced mixture identifier – goes to the mixture's definition.
- Referenced Geometry unit identifiers (holes) – goes to the unit definition.

Cursor context used in definition look up and navigation

```
51 media 3 1 99 -6
52 boundary
53 end geometry
54 '-----'
55 ' Definition
56 '-----'
57 read definit
58 response
59 titl
60 dose
61 end resp
62
63 distribu
64 titl
65 disc
66 true
67 end dist
68 gridGeom
```

```
17 =mavric
18 AOS-100: Demonstrate use of MG importance maps with final MC using CE tran
19 v7-200n47g
20
21 '-----'
22 ' Composition Block - standard SCALE input
23 '-----'
24 read composition
25 ss304 1 end
26 wtptTungsten 2 17.8 4 74182 26 74183 14 74184 31 74186 29 end
27 dry-air 3 end
28 end composition
29
```

# Miscellaneous : Math Evaluations

Often engineering specifications require conversion to input specifications. Even if a calculator is readily available, a human component is required to enter the converted (e.g, inches to centimeters) value into the input. Fulcrum provides an inline math expression evaluator.

- Removes/mitigates typographical errors related to converted numeric input entry.
- Encourages documentation of engineering specifications that require conversion.
- Full complement of math functions available :
  - +, -, \*, /, ^, sqrt, cos, sin, root, abs, min, max, avg, sum, mul, floor, ceil, exp, log, logn, log10, hyp, if, clamp, inrange, sign, deg2rad, tan, equal, acos, asin, atan, cosh, tanh, sec, csc, cot, sinh, round, roundn, d2g, g2d, r2d
- Evaluation occurs on highlighted text.

The image displays two side-by-side screenshots of the SCALE software interface, illustrating the inline math expression evaluator. Both screenshots show a code editor window titled 'mavric.aos100.inp\*' with a menu bar (File, Edit, View, Run, Help) and a toolbar (Reload, Save, Save as, Close tab, Print, Cut, Copy, Paste, Undo, Redo, Find). The code editor shows a code block with the following content:

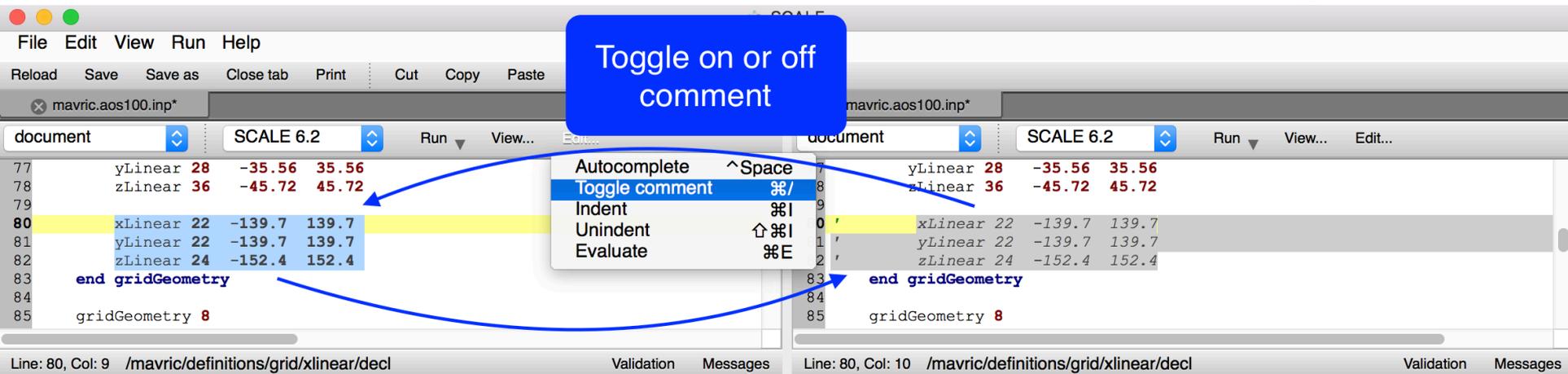
```
34 '-----  
35 ' Geometry Block - SCALE standard geometry packa  
36 ' Input units in centimeters  
37 '-----  
38 read geometry  
39   global unit 1  
40   ' Cavity cylinder in inches is specified as  
41   ' radius=20.9677 height=129.032 located at z=-64.516  
42   cylinder 1 20.9677/2.54 (-64.516 + 129.032)/2.54
```

In the left screenshot, the expression `(-64.516 + 129.032)/2.54` is highlighted in yellow, and a context menu is open over it with the 'Evaluate' option selected. The right screenshot shows the same code block, but the expression has been evaluated, and the result `25.4` is displayed next to it, resulting in the line: `cylinder 1 20.9677/2.54 25.4 -64.516/2.54`. A blue callout box with the text 'Math expressions and evaluation' has arrows pointing to the highlighted expression and the resulting value. The status bar at the bottom of each window shows 'Line: 42, Col: 36 / Validation Messages' and 'Line: 42, Col: 42 / Validation Messages'.

# Miscellaneous : Comment Toggle

Comment toggling allows users to quickly comment or uncomment pieces of input.

- Allows comment creation.
- Mitigates user needing to recall what a comment looks like.
- Assists in input development iterations.
- CMD+/ on OS X and CTRL+/ on Windows and Linux.



# Miscellaneous : Input Indent/Unindent

Hierarchical input (Sequence > Read Block > Component Record) can be depicted using levels of indentation. Input indent and unindent facilitates quick formatting to visually depict hierarchy.

The image displays two screenshots of the SCALE software interface, illustrating the use of the Indent and Unindent menu options. Both screenshots show a code editor window with a menu open over the code.

**Top Screenshot: Indent selected text a tab (4 spaces)**

The code editor shows the following code:

```
77 yLinear 28 -35.56 35.56
78 zLinear 36 -45.72 45.72
79
80 xLinear 22 -139.7 139.7
81 yLinear 22 -139.7 139.7
82 zLinear 24 -152.4 152.4
83 end gridGeometry
84
85 gridGeometry 8
```

The menu options are:

- Autocomplete ^Space
- Toggle comment ⌘/
- Indent ⌘I**
- Unindent ⇧⌘I
- Evaluate ⌘E

**Bottom Screenshot: Unindent selected text a tab (4 spaces)**

The code editor shows the same code as the top screenshot. The menu options are:

- Autocomplete ^Space
- Toggle comment ⌘/
- Indent ⌘I
- Unindent ⇧⌘I**
- Evaluate ⌘E

The status bar at the bottom of both screenshots indicates: Line: 80, Col: 1 /mavric/definitions/grid

# Miscellaneous : File Autosaves

Any file Fulcrum edits - currently only text files - are immediately backed up to a *filename.fulcrum.autosave*. In the scenario that Fulcrum or the application or computer crashes the autosave file will persist.

- Upon Fulcrum restart, when reloading the original file, Fulcrum will check for *filename.fulcrum.autosave* and load this instead, mitigating any lost progress.
- A save of the file will remove the autosave.

# Input Editor : Future Features

- Enhanced cursor context presentation.
  - Display input record information under cursor with labels.
  - Linked help documentation – press F1 and get help section describing the input record under the cursor.
- Enhanced input component forms.
  - Allows displaying input record/block under cursor in a visual form – allows seamless input text to form round-tripping without loss of input formatting or input [quality assurance] comments.
- Input Differences.
  - Visually difference two inputs.
- Enhanced output review capability.
  - Warning and error quick navigation.
  - Upgraded HTML output.

# Summary

- Fulcrum Input Editor Components
- Text Editor Settings
  - Syntax colors and default editor behaviors
- Syntax Highlighting
  - Input component color
- Document Quick Navigation
- Cursor Context
  - Formal location in the input document
- Input Block Start and End Highlighting
- Input Autocompletion
  - Creation and editing of input
- Input Validation
  - Simple and complex
- Input Execution
  - customizable
- Output File Viewing
- Miscellaneous Features
  - Find/Replace
  - Column select/edit
  - Comment toggle
  - Selection indent/unindent
  - Inline math evaluations
- Future Features coming soon to a Fulcrum on your desktop

# Exercise 1 : Lady Godiva

Create the Lady Godiva experiment using CSAS6.

Problem definition :

Lady Godiva consists of **17.482** cm diameter sphere.

Run **V7-252 multiregion** cross section with **vacuum right boundary** condition, and **10000 particles per generation** with **200 generations skipped**.

Isotope	Atomic Number Density
U-234	0.000491995
U-235	0.0449996
U-238	0.002498

# Exercise 1 : Lady Godiva

Purpose :

- 1) New Input creation.
- 2) Autocompletion of input.
- 3) Execution and output viewing.

# Exercise 1 : Lady Godiva : Task 1

Creation New document named InputEditorExercise1.inp

- File>New File...
- Specify InputEditorExercise1.inp.

You should now have a blank input file.

# Exercise 1 : Lady Godiva : Task 2

Autocomplete a **csas6** sequence.

- With cursor in text editor, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination.
- Select the **csas6 – Criticality safety analysis using KENO-VI**.
- Change ‘title-goes-here’ to ‘Lady godiva.’
- Change ‘xslib-goes-here’ to ‘v7-252.’

You should now have an input file with minimum required input blocks. Notice the validation errors indicating what is needed.

# Exercise 1 : Lady Godiva : Task 3

Autocomplete 3 **stdcomps** with **atomic density** and **temperature** for the listed isotopes.

- With cursor in comps block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **stdcomp – basic + atomic density + temperature**.
- Update the isotope and atomic density (**aden**)
- Repeat the above 2 steps for each isotope in the table.

You should now have a complete composition block.

Isotope	Atomic Number Density
U-234	0.000491995
U-235	0.0449996
U-238	0.002498

# Exercise 1 : Lady Godiva : Task 4

Autocomplete the cell block and **17.482 diameter spherical multiregion cell**.

- With cursor below the comps block and above the geometry block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **cells**.
- With cursor in the cells block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **multiregion - spherical**.
- Update the multiregion zone input to reflect the proper sphere **radius**.

You should now have an input with complete comp and cell data. The validation messages should indicate error about global unit's missing media,hole, etc.

# Exercise 1 : Lady Godiva : Task 5

Autocomplete the sphere.

- With cursor below the global unit and above the unit boundary, select **Edit>Autocomplete**, or press **CTRL +SPACE** key combination and select the **sphere**.
- Update the sphere **radius** to the appropriate value.

You should now have an input with a sphere region specified but no media.

# Exercise 1 : Lady Godiva : Task 6

Autocomplete the media.

- With cursor below the sphere and above the unit boundary, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **media**.

You should now have an input with a sphere region specified and media. Notice the media material and region definition vector was updated as the default values matched the generated material id from task 3 and 5.

There should be no validation errors.

# Exercise 1 : Lady Godiva : Task 7

Execute the first input iteration.

- Click the Run button.
- Click the Messages panel.
- Note the k-eff value of  $\sim 1.0007 + \text{ or } - 0.0016$ .

At this point you should have a functioning input, that needs a parameter block.

# Exercise 1 : Lady Godiva : Task 8

Autocomplete the parameter block and run again.

- With cursor below the cells block and above the geometry block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **parameters**.
- With cursor in the parameter block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **npg – no. per generation**. Update to **10000**.
- With cursor in the parameter block, select **Edit>Autocomplete**, or press **CTRL+SPACE** key combination and select the **nsk – generations skipped**. Update to **200**.
- Click the Run button.
- Click the Messages panel.
- Note the k-eff value of  $\sim 0.9999 + \text{ or } - 0.0044$

# Exercise 1 : Lady Godiva : Task 9

Open the output.

- In the document **Navigation** panel right click the InputEditorExercise1.inp file.
- Mouse over Open associated files.
- Select the InputEditorExercise1.out file.
- Conduct a find on 'best estimate.'
- Notice the expected value.

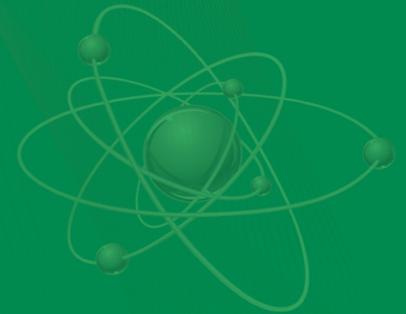
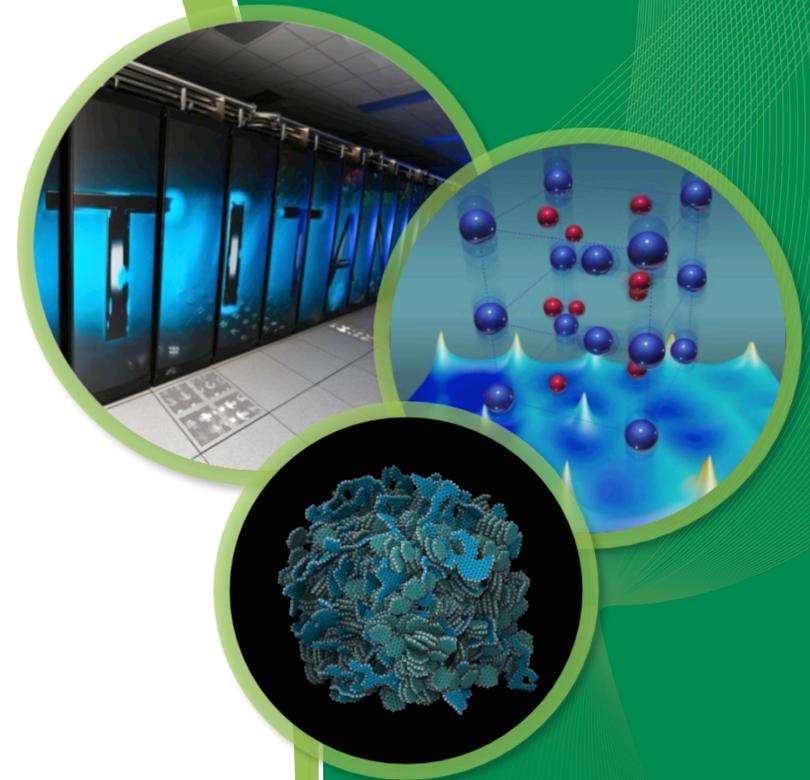
Exercise complete.

# Fulcrum User Interface

## Plot Data Overview

Robert A. Lefebvre

October 2016

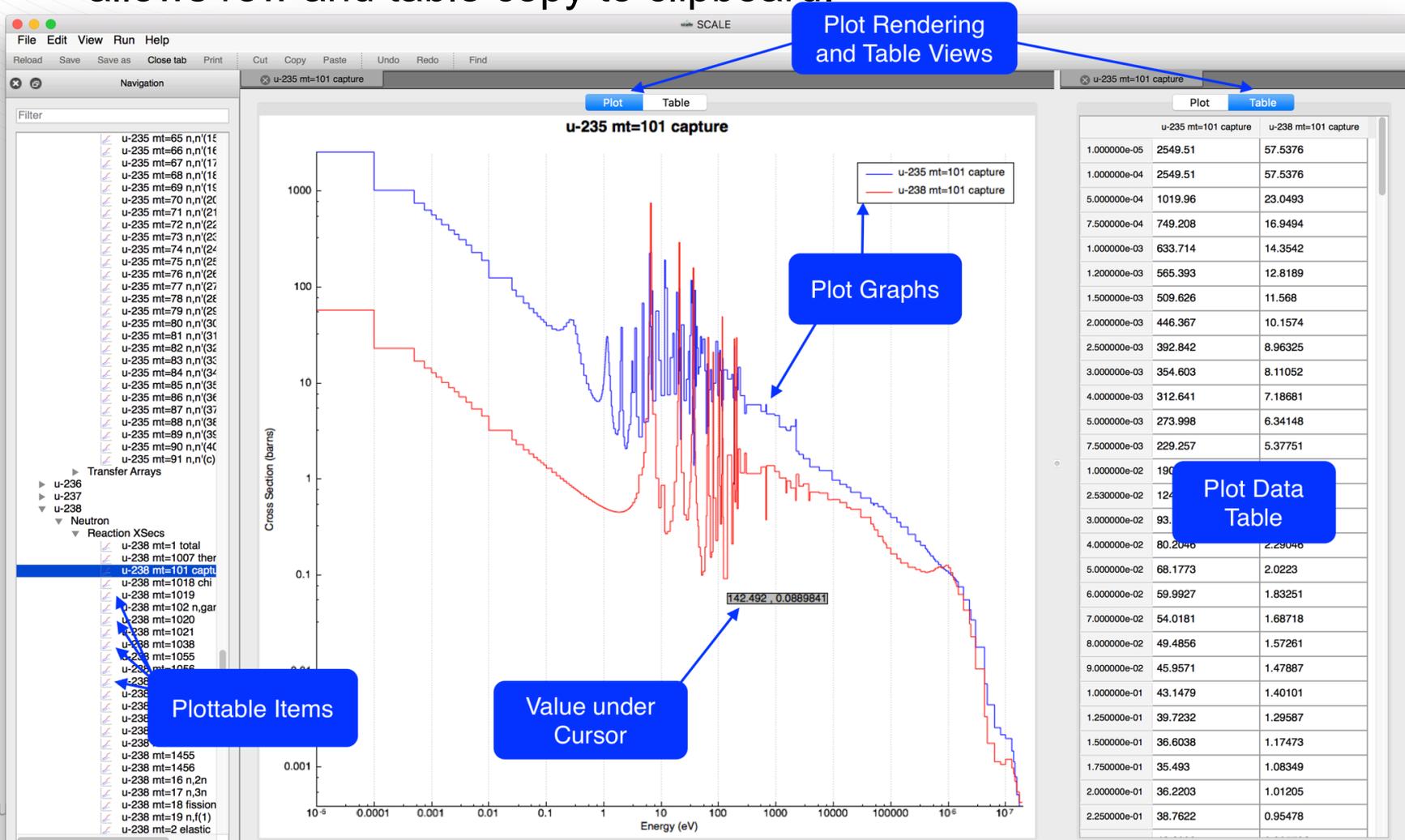


# Presentation Outline

- General Plot Overview
- Plot Controls
- AMPX Cross Section Data
- Covariance Data
- ORIGEN Isotope Concentration Data (F71)
- F71 Special Plot Controls (PlotOPUS)
- ORIGEN Gamma Data
- General Output Result Plots

# General Plot Overview

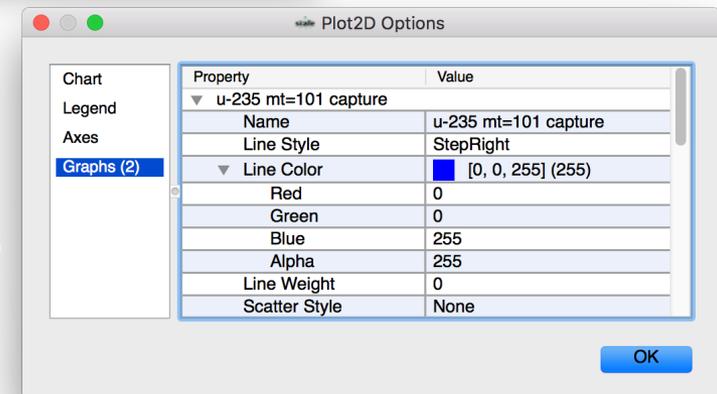
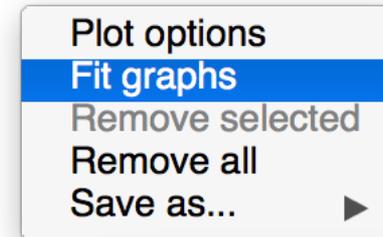
- Interactive and configurable plot rendering
- Plot data table displays graph data.
  - allows row and table copy to clipboard.



# Plot Controls

Fulcrum plots consist of graph, bars, or color maps, which can be manipulated as follows.

- Select graph via left click in plot or legend.
  - Remove selection via context menu 'Remove selected'
- Zooming is performed via the mouse scroll action.
  - Zoom in by scrolling up.
  - Zoom out by scrolling down.
- Reset to original via context menu Fit graphs.
- Panning is performed via a click and drag.
  - Pan right by left clicking and dragging left.
  - Pan up by left clicking and dragging down.'
- Save Plot as
  - PDF (includes scalable vector graphics SVG),
  - PNG and JPG image format
  - Interactive Scale Plot Format (SPF)
- Plot attributes (color, style, etc.) can be changed via context menu Plot options.
- Plot Legend can be drug to 9 cardinal positions via left-click and drag.



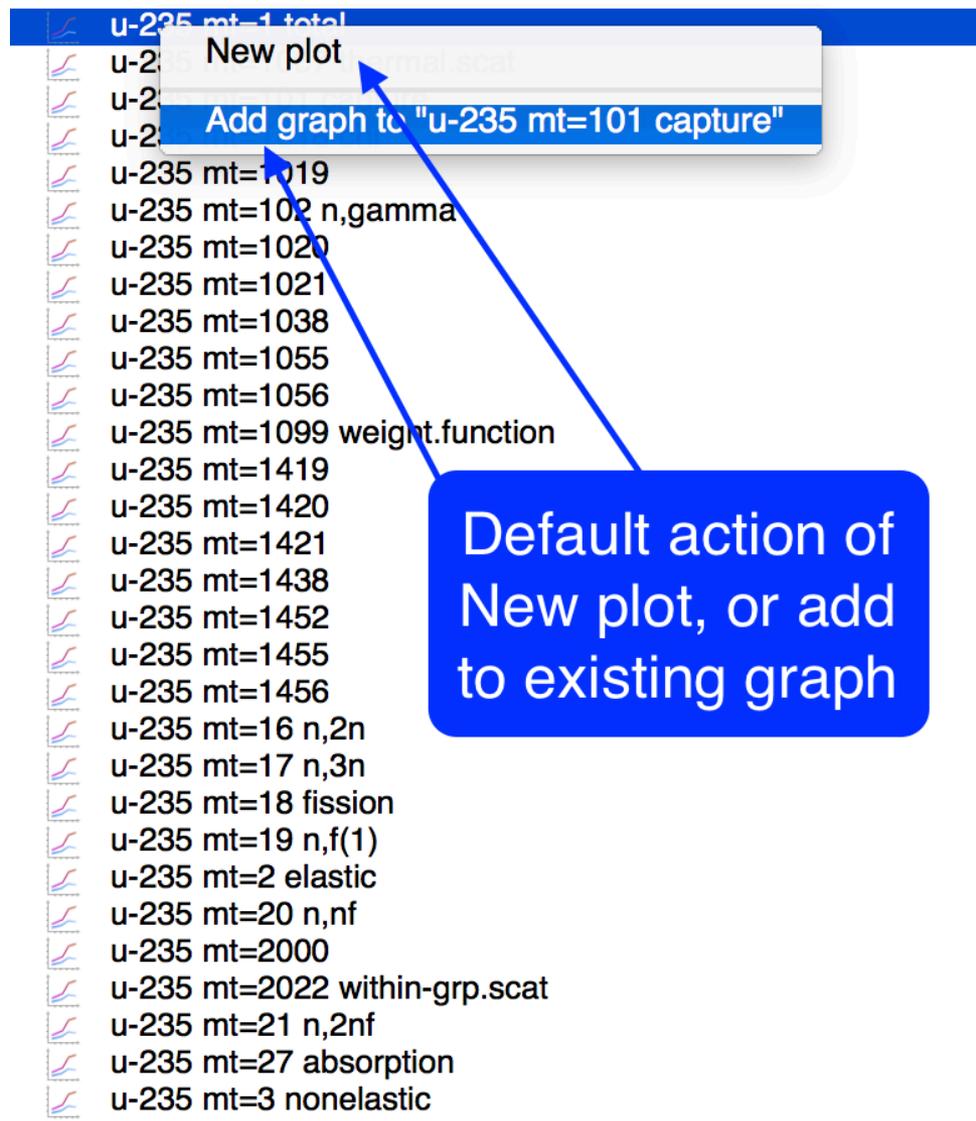
# Plot Controls : Plot Options

- Chart – Allows changing the plot title and title visibility.
- Legend – Allows changing the legend's font and visibility.
- Axis – Allows changing axis visibility, label text, label text font, axis scale, axis range, axis grid, tick label font and tick text attributes (rotation, precision, etc.).
- Graphs – Allows changing graph name, line style, line color, line weight, scatter style, scatter size, pen style, adaptive sampling\*, errors bars.
- Bars – Allows changing bar graph name.
- Color Map – Allows changing color map graph name and color gradient.

# Plot Controls : Plot Creation

Plots can be created standalone or added to existing.

- Double left-click a plot to create a new plot.
- Alternatively, right click and select New plot.
- Add to preexisting plot via a right click and selecting Add graph to....
  - Add is only available for plots with matching axes.



# AMPX Cross Section Data

AMPX Cross Section Data is available in multigroup (MG) and continuous-energy form and is located at  $\{\text{SCALE}\}/\text{data}$ . Because the files do not have a unique extension, the user must load them specifically by type.

- Load MG XS data via File>Open multigroup library...
- Load CE XS data via File>Open continuous-energy library...
- CE XS data are displayed hierarchically
  - by Neutron or Photon, Isotope, Temperature (K), and Reaction.
- MG XS data are displayed hierarchically
  - By Isotope, Neutron or Gamma, Reaction XS or transfer array.

The screenshot shows the AMPX software interface. At the top, a search bar contains the text `^u(*!-235)mt=(11502) |`. Below it is a hierarchical tree view of cross-section data. The tree is organized as follows:

- ce\_v7.1\_endf.xml
  - Neutron
    - u-235
      - 293
        - u-235 mt=1 total
        - u-235 mt=1 total 293 K xs
- Photon
  - u
    - u mt=502 photon.coh.scot
    - u mt=502 photon.coh.scot xs
- scale.rev12.xn28g19v7.1
  - u-230
  - u-231
  - u-232
  - u-233
  - u-234
  - u-235
    - Gamma
      - Reaction XSecs
        - u-235 mt=502 photon.coh.scot
      - Transfer Arrays
        - 0K
          - mt=502 photon.coh.scot
            - u-235 mt=502 photon.coh.scot 0K p0
            - u-235 mt=502 photon.coh.scot 0K p1
            - u-235 mt=502 photon.coh.scot 0K p2
            - u-235 mt=502 photon.coh.scot 0K p3
            - u-235 mt=502 photon.coh.scot 0K p4
            - u-235 mt=502 photon.coh.scot 0K p5
    - Neutron
      - Reaction XSecs
        - u-235 mt=1 total

Two blue callout boxes provide additional information:

- The top callout box, titled "Continuous Energy :", explains that data is organized by type (Neutron, Photon), isotope, temperature (K), and reaction.
- The bottom callout box, titled "Multi group :", explains that data is organized by isotope, type (Gamma, Neutron), dimension (1d - reaction xs, 2d - transfer array), temperature, and reaction.

In the bottom left, a file menu is open, showing options such as "New file...", "Open file...", "Open multigroup library..." (highlighted), "Recent files", "Reload", "Save", "Close", and "Print".

# Plot Exercise 1

Description:

Compare the **252 MG** vs. **CE U-235 Fission** cross section at **293K** and produce a **PDF** of the **108 barn** peak between **0.1-10 eV**.

Intent:

Familiarity with loading CE and MG libraries.

Familiarity with plot controls (zoom and pan).

Familiarity with combining plots.

Familiarity with saving plots.

# Plot Exercise 1 : Task 1

1. Load CE V7.1 ENDF library from the SCALE/data directory.
2. Find the U-235 Isotope at 293K.
3. Double click the 293 navigation item to load the reactions at that temperature.
4. Find the U-235 mt=18 fission 293 K xs entry.
5. Double click the entry to create a 2D plot.
6. Done.

# Plot Exercise 1 : Task 2

1. Load 252 group MG library from the SCALE/data directory.
2. Find the U-235 Isotope Neutron Reaction XSecs entry.
3. Find U-235 mt=18 fission entry.
4. Right click the entry to obtain a popup context menu.
5. Click the Add to graph to... menu item.
6. Done.

# Plot Exercise 1 : Task 3

1. Pan the plot to be centered at 1 eV.
  - Left click and drag
2. Zoom the plot to the requested eV range.
  - Scroll up zooms in.
3. Repeat steps 1 and 2 as needed to center plot about the ~108 barn cross section peak near 1 eV.
4. Right click to obtain the plot context menu.
5. Select Save as>PDF and specify PlotExercise1.pdf.
6. Done

Exercise complete.

# Covariance Data

Covariance Data is available at SCALE/data. Because the files do not have a unique extension, the user must load them specifically by type.

- Correlation coefficient matrix color map plots
- Covariance matrix color map plots
- Isotope Reaction Standard Deviation by energy or group graph plots

New file... ⌘N  
 New ORIGAMI Automator project... ⇧⌘N

Open file... ⌘O  
 Open ORIGAMI Automator project... ⇧⌘O  
 Open ORIGEN concentration file...  
 Open UNF-ST&DARDS time series...

Open multigroup library...  
 Open continuous-energy library...  
**Open covariance library...**  
 Open ORIGEN gamma data...

Recent files  
 Recent ORIGAMI Automator...

Reload

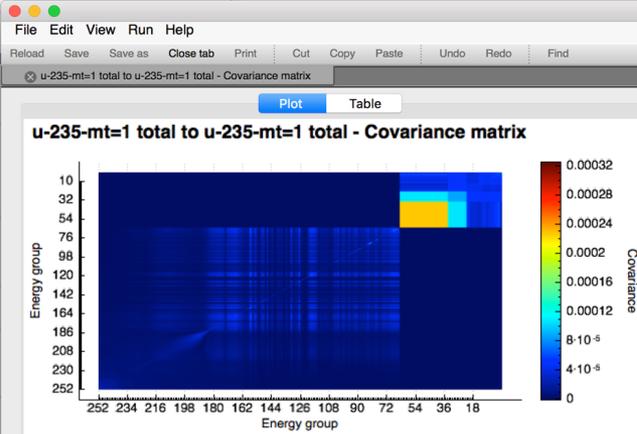
Save  
 Save as...  
 Save all

Close  
 Close all

Print

Settings...  
 Reset settings

Exit



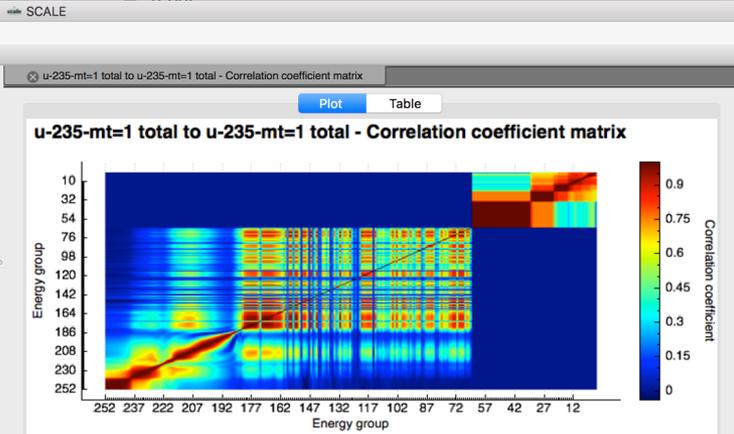
Navigation

u-235

- u-235
  - mt=1 total
    - u-235
      - u-235-mt=1 total to u-235-mt=1 total
        - u-235-mt=1 total to u-235-mt=1 total - Correlation coefficient matrix
        - u-235-mt=1 total to u-235-mt=1 total - Covariance matrix
      - u-235-mt=1 total to u-235-mt=102 n,gamma
        - u-235-mt=1 total to u-235-mt=102 n,gamma - Correlation coefficient matrix
        - u-235-mt=1 total to u-235-mt=102 n,gamma - Covariance matrix
      - u-235-mt=1 total to u-235-mt=18 fission
        - u-235-mt=1 total to u-235-mt=18 fission - Correlation coefficient matrix
        - u-235-mt=1 total to u-235-mt=18 fission - Covariance matrix
      - u-235-mt=1 total to u-235-mt=2 elastic
        - u-235-mt=1 total to u-235-mt=2 elastic - Correlation coefficient matrix
        - u-235-mt=1 total to u-235-mt=2 elastic - Covariance matrix
      - u-235 mt=1 total - Std dev by energy**
      - u-235 mt=1 total - Std dev by group
    - mt=1018 chi
    - mt=102 n,gamma
    - mt=16 n,2n
    - mt=18 fission
    - mt=2 elastic
    - mt=4 n,n'
      - u-235
        - u-235-mt=4 n,n' to u-235-mt=2 elastic
          - u-235-mt=4 n,n' to u-235-mt=2 elastic - Correlation coefficient matrix
          - u-235-mt=4 n,n' to u-235-mt=2 elastic - Covariance matrix
        - u-235-mt=4 n,n' to u-235-mt=4 n,n'
          - u-235-mt=4 n,n' to u-235-mt=4 n,n' - Correlation coefficient matrix
          - u-235-mt=4 n,n' to u-235-mt=4 n,n' - Covariance matrix
        - u-235 mt=4 n,n' - Std dev by energy
        - u-235 mt=4 n,n' - Std dev by group
    - mt=452 nubar
      - u-235
        - u-235-mt=452 nubar to u-235-mt=452 nubar
          - u-235-mt=452 nubar to u-235-mt=452 nubar - Correlation coefficient matrix
          - u-235-mt=452 nubar to u-235-mt=452 nubar - Covariance matrix

Correlation Coefficient and Covariance Matrix Color Map Plots

Standard Deviation Graph Plots



Correlation coefficient matrix

Correlation coefficient matrix

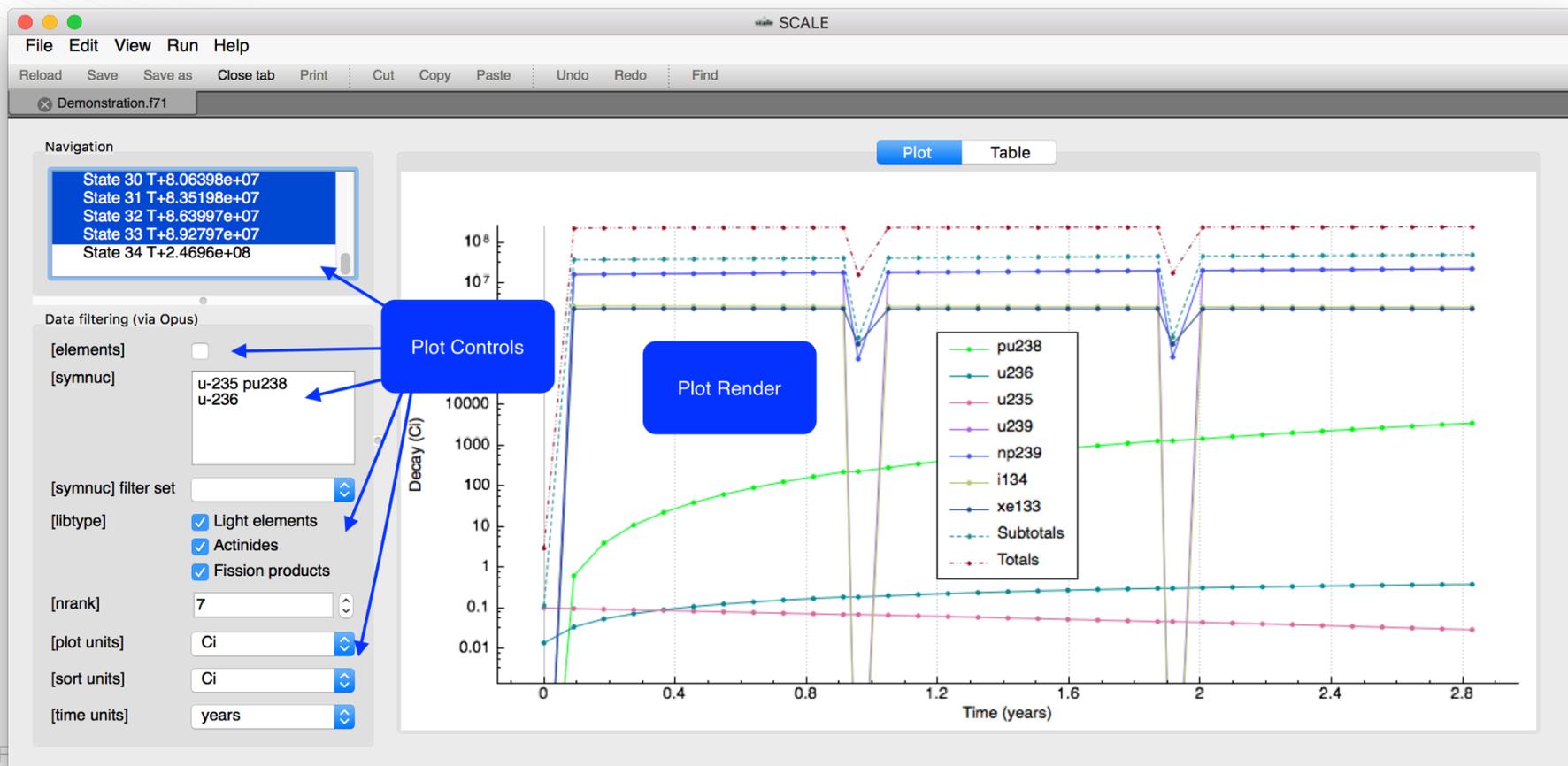
Correlation coefficient matrix

Covariance matrix

# ORIGEN Isotope Concentration Data (F71)

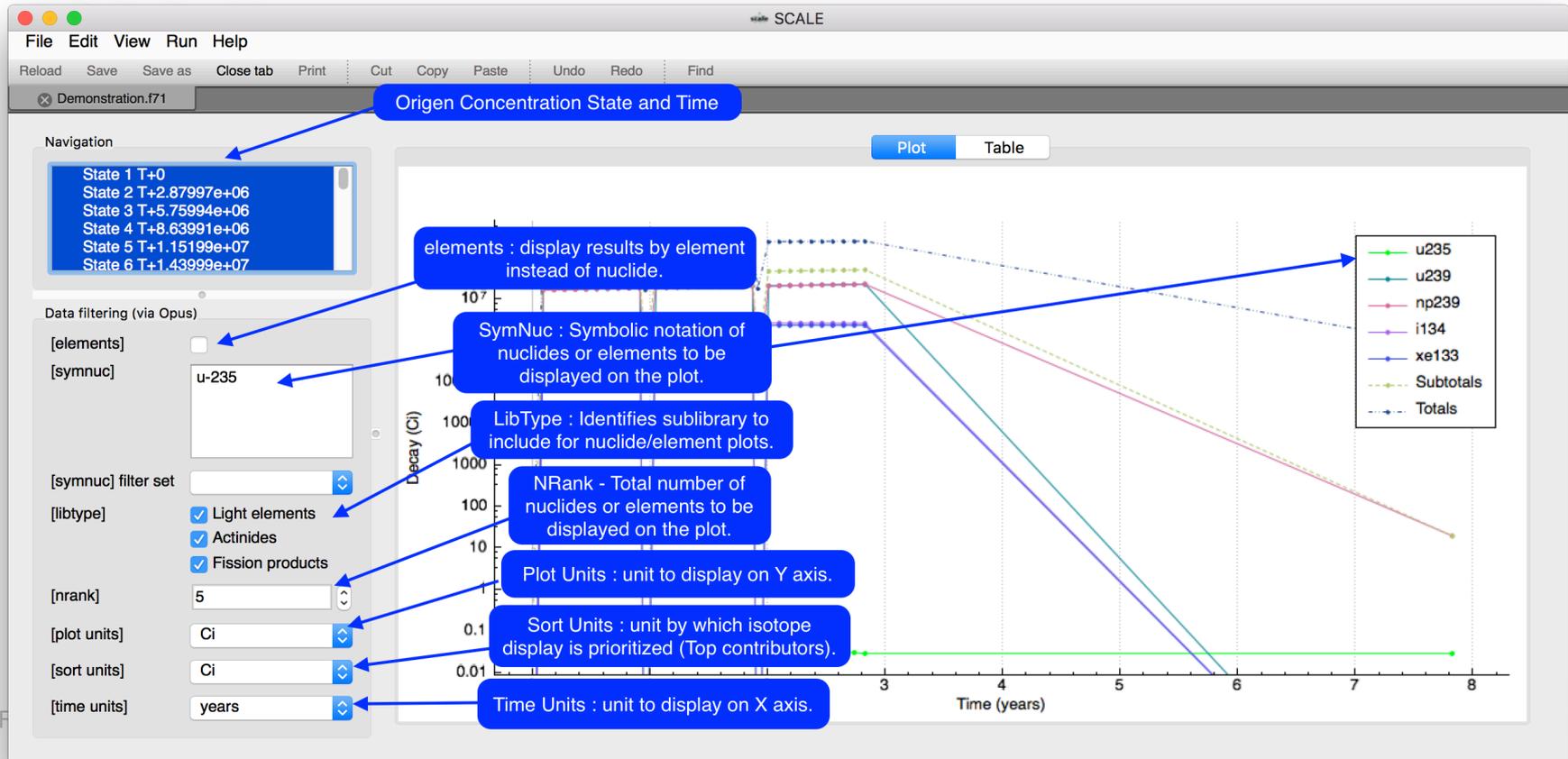
Origen concentration data contains results from depletion, decay, and activation calculations. The plot capabilities are centered about the expected Fulcrum interactive plot with the addition of a more familiar PlotOPUS style set of controls.

- Easy selection of state information to display.
- Easy display of nuclides or elements by id or category.
- Easily display different units (Decay, Mass, Number).



# F71 Special Plot Controls (PlotOPUS)

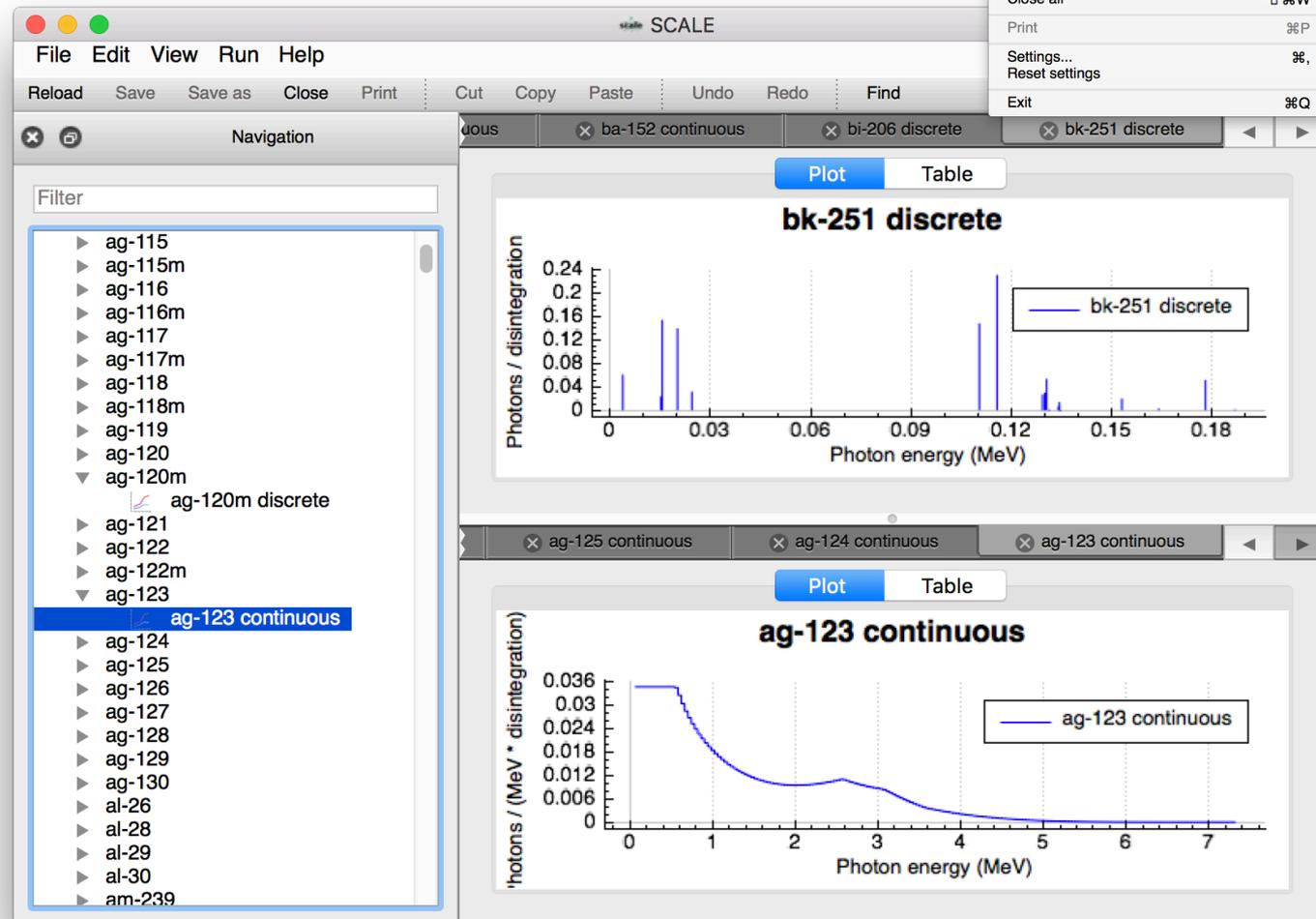
- Navigation allows selection of state information at a given time point.
- Element allows display of results by element instead of nuclide.
- SymNuc allows specifying nuclides or elements to include in the plot.
- Libtype allows display of nuclides or elements contained in the light elements, actinides, and fission product isotope sets.
- Nrank allows limiting the display of the top contributors.
- Time, Plot, and Sort Units allows changing the X and Y axis and the nuclides or elements displayed based on contribution.



# ORIGEN Gamma Data

The master photon data library, located at `SCALE/data/origen_data/origen.rev###.mpdkxgam.data`, provides both discrete and continuous energy gamma lines.

- Opened via File>Open ORIGEN gamma data...

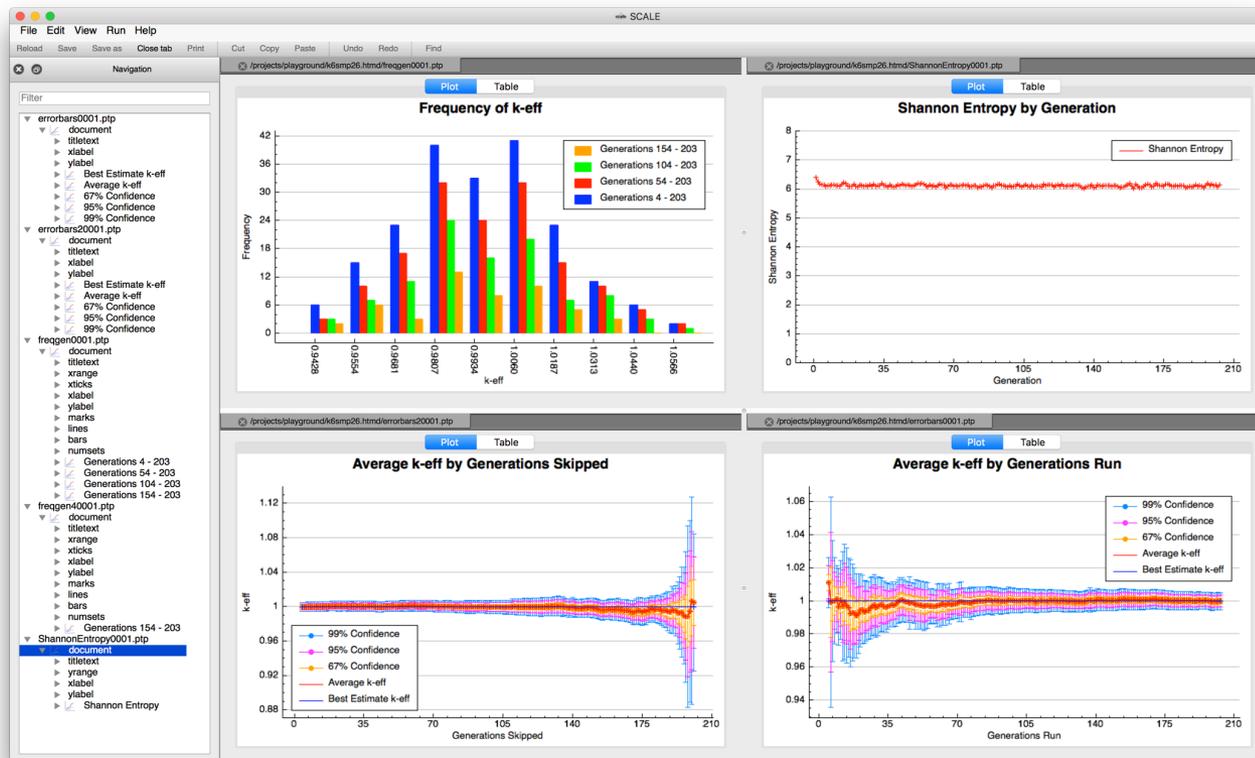


# General Output Result Plots

- Keno k-effective By Generation.
- Keno Frequency Distributions.
- Keno Flux.
- Keno Final edit of fissions, absorptions, and leakage.
- MAVRIC batch convergence data for point detector and region tallies.
- MAVRIC response input and multigroup representation.
- Sampler histograms, histories, running averages, and scatter plots.
- Opus Plots (plt)
- And others...

# Keno Result Plots

- Plot of average k-effective by generation run
- Plot of average k-effective by generations skipped
- Final edit of fissions, absorptions, and leakage
- Frequency distributions
- Shannon Entropy
- Flux plotting



# Summary

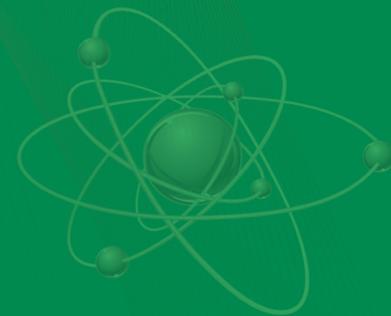
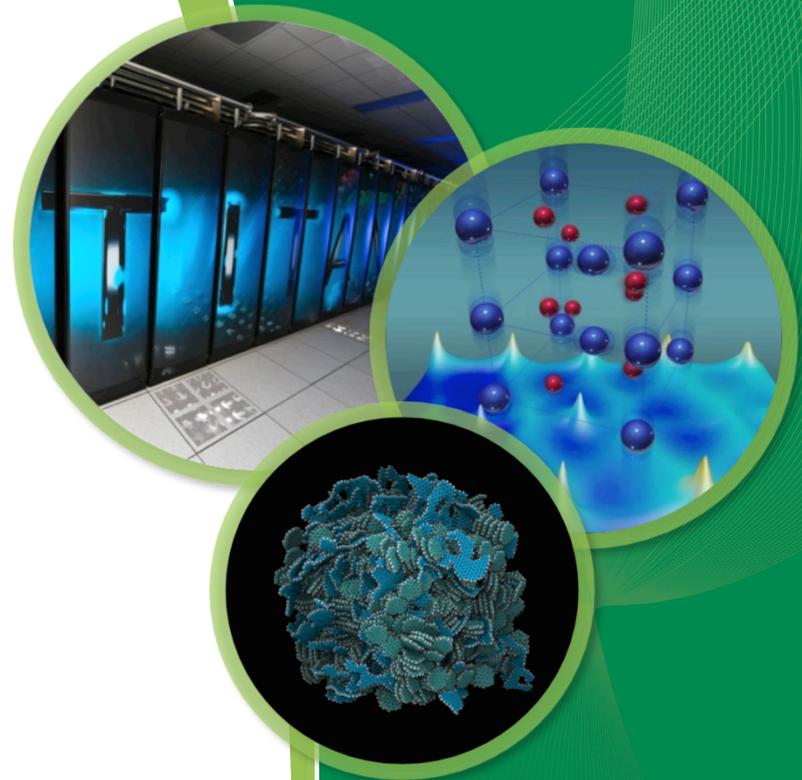
- Plot Overview
- Interactive plot controls
- AMPX Cross Section Data
- Covariance Data
- ORIGEN Isotope Concentration Data (F71)
- F71 Special Plot Controls (PlotOPUS)
- ORIGEN Gamma Data
- General Output Result Plots
- Questions?

# Fulcrum User Interface

## Geometry Viewer Overview

Robert A. Lefebvre

October 2016



# Presentation Outline

- Geometry Viewer Overview
- Activating the Geometry Viewer
- Viewer Controls
- Axis Views
- Render Modes
- Geometry Magnification
- View Origin
- Show View Origin
- View Origin Preserved Across View Plane (Top to Front, etc.)
- Geometry Error Presentation
- Miscellaneous Features
- Mesh Overlay Overview
- Mesh Overlay Supported Formats
- Mesh Overlay Controls
- Future Features

# Geometry Viewer Overview

Geometry viewer uses ray tracing to present a perspective as close to the particle transport as possible to the user.

The screenshot shows the SCALE Geometry Viewer interface. At the top, the menu bar includes File, Run, and Help. Below it, a toolbar contains icons for Reload, Close tab, Print, Cut, Copy, Paste, and Undo. The main window title is "SCALE".

Key components and their labels:

- Axis Views:** A set of buttons for "Top (X-Y)", "Front (X-Z)", "Side (Y-Z)", "3D", and "Meshes".
- Geometry Viewer Tab:** Shows the originating line number to disambiguate multiple geometries (e.g., "mavric.aos100.inp : geometry (Line 37)").
- Available Meshes:** A list of meshes including "mavric.aos100.adjoint.dff" (with sub-items "Adjoint Neutron flux" and "Adjoint Photon flux") and "mavric.aos100.mt1.3dmap" (with sub-items "Photon Flux" and "Responses").
- Material:** A dropdown menu currently set to "Material".
- 1.0000x zoom:** A zoom control with a scroll wheel.
- Show view origin:** A button to toggle the display of the view origin.
- Render mode drop-down:** A dropdown menu for selecting the render mode.
- View zoom display and control:** A label for the zoom control.
- Display crosshair at view's origin:** A label for the crosshair in the center of the render area.
- Geometry Render Area:** The main 3D rendering area, currently showing a green background with a blue circular crosshair.
- View plane slide control - changes elevation of view plane:** A slider control on the right side of the render area.
- View origin display and controller:** A label for the origin display and controller.
- Under-cursor Information:** A label for the information displayed at the bottom left.

At the bottom left, the coordinates are displayed: "X: 0.6181416; Y: 34.6159292; Unit: 1; Mixture: 1". At the bottom right, the view origin is displayed: "View origin: (0, 0, 0)".

# Geometry Viewer Overview

- Axis Views provide 2D axis-aligned geometry renderings.
- Available Meshes to Overlay allows combining geometry rendering with mesh-based results.
- Render Modes – toggle between different material, outline, and mesh overlay render modes.
- Show view origin – highlights exact point at center of view with crosshair.
- Position, Unit, and Mixture under Cursor – communicates geometry information under mouse cursor.
- View origin – displays and provides control of the origin of the view.
- Axis view plane slide controller – interactively manipulates the elevation of the view plane.
- Context Menu (via right click) – allows changing color and saving images.

# Activating the Geometry Viewer

Activating the geometry viewer can be accomplished via the Input Editor's View...>View geometry button or the Document Navigation geometry item's popup context menu.

- If multiple geometry input blocks exist in the document, a selection will be provided.

The screenshot shows the SCALE software interface. The Document Navigation tree on the left shows a hierarchy: `mavric.aos100.inp` > `document` > `mavric` > `geometry`. A blue box labeled "Visualize" points to the `geometry` item. A blue box labeled "Popup Context Menu in Document Navigation tree" is shown over the `geometry` item. The Input Editor on the right shows the text of the `geometry` block, with a blue box labeled "View geometry" pointing to the `View geometry` button. A blue box labeled "Input Editor's View Geometry Button" points to the `View geometry` button. A separate window titled "Visualize" is shown in the bottom left, with a dropdown menu showing "geometry (line 119)" and "Cancel" and "OK" buttons.

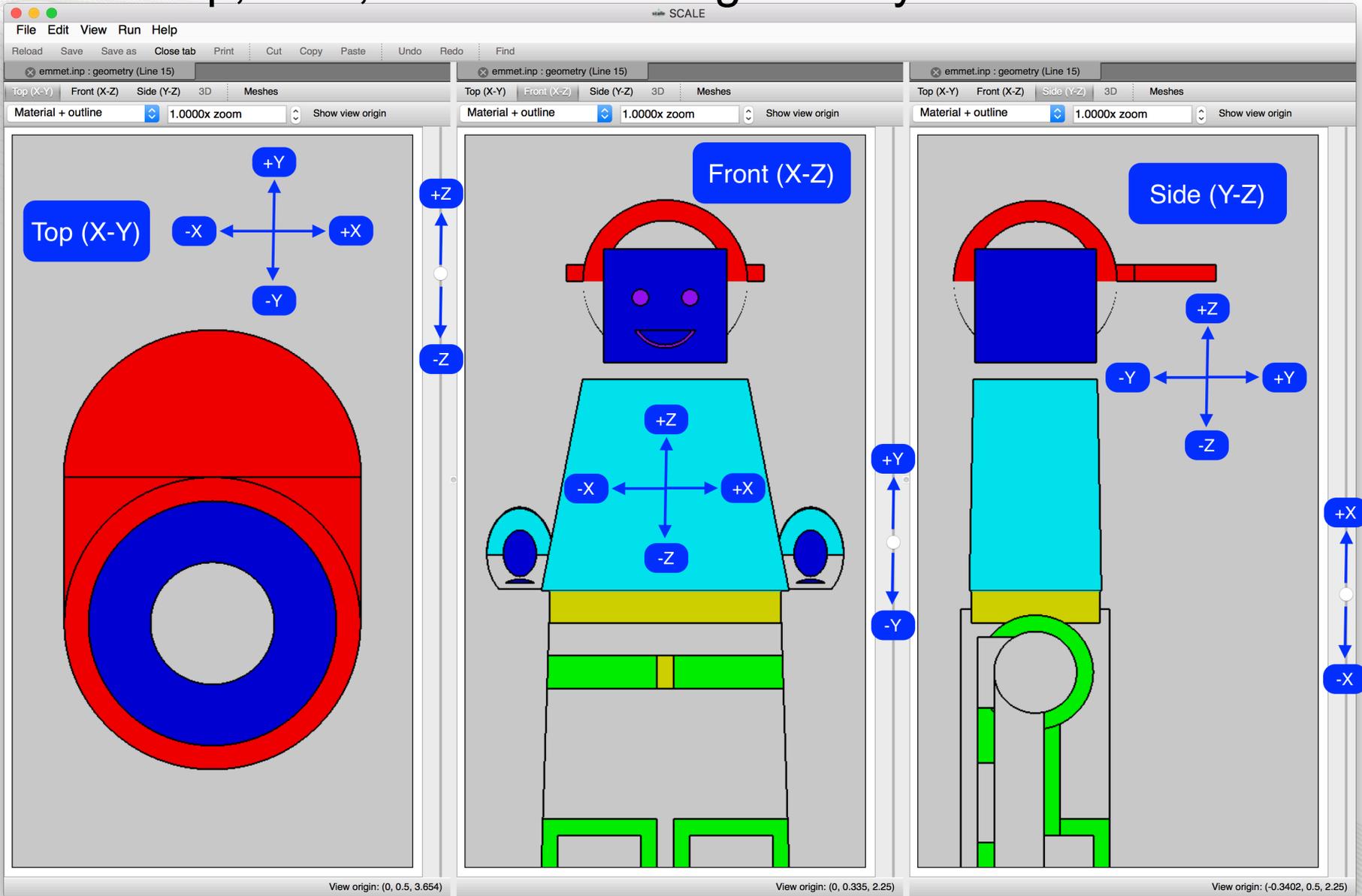
# Geometry Viewer Controls

Geometry viewer controls facilitate manipulation of the geometry rendering.

- Axis (X,Y,Z) rendered.
  - Top (X-Y) – view plane intersects Z axis.
  - Front (X-Z) – view plane intersects the Y axis.
  - Side (Y-Z) – view plane intersects the X axis.
- Elevation (axis intersection) of the view plane rendered.
- Type of rendering.
  - material, outline, mesh, etc.
- View origin (point at center of view plane).
- Geometry Magnification.

# Axis Views

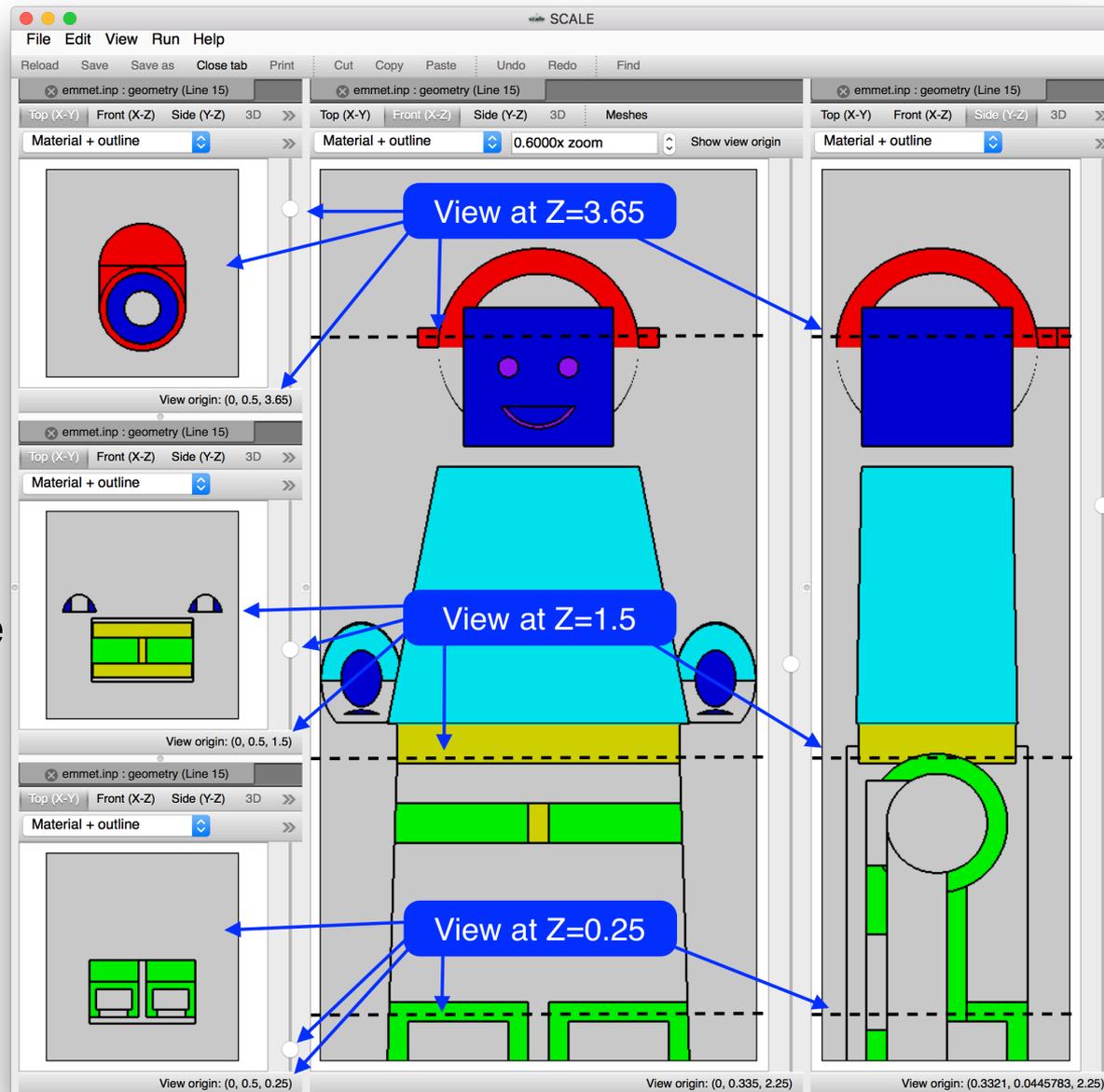
- Axis views provide standard orthographic model projections of the top, front, and side of the geometry.



# Axis Views : Elevation Control

View plane elevation is controlled via a slide control on the right side of each geometry view.

- View plane elevation corresponds to view plane control – the higher the slider control, the higher the view plane.
  - Top (X-Y) - raising the slider increases the Z intersect.
  - Front (X-Z) – raising the slider increases the Y intersect.
  - Side (Y-Z) – raising the slider increases the Z intersect.

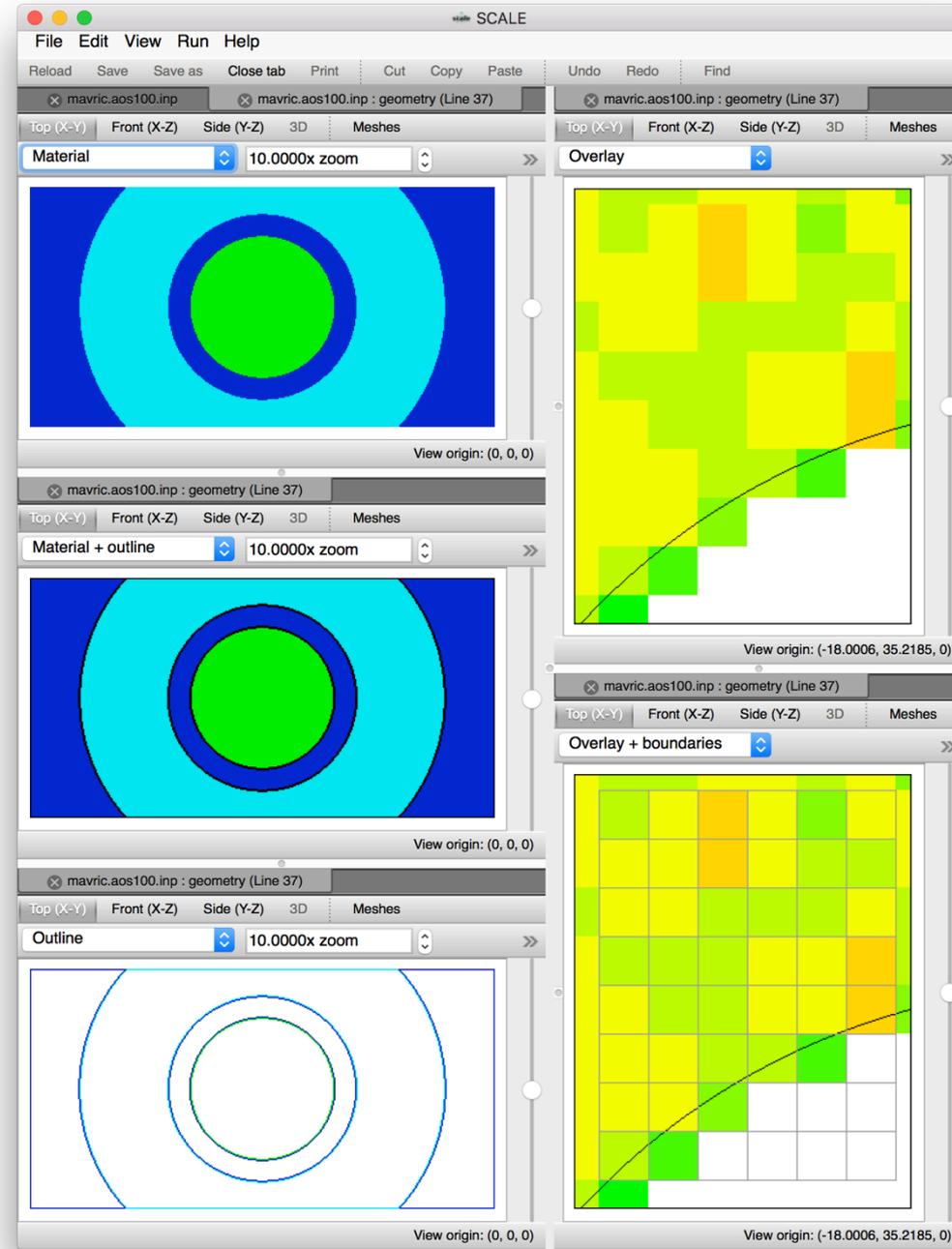


- ✓ Material
- Material + outline
- Outline
- Overlay
- Overlay + boundaries

# Render Modes

Render modes control the information displayed.

- Material displays only the materials/mixtures.
  - Can hide geometry region outlines that are the same material.
- Material + outline displays the material and the region outlines.
  - Displays region outline in black.
  - Useful for contrasting geometry regions.
- Outline displays only geometry region outlines.
  - Displays region outline in material color.
- Overlay displays geometry region outline and mesh data results.
- Overlay + boundaries displays geometry region outline, mesh boundaries\*, and mesh data results

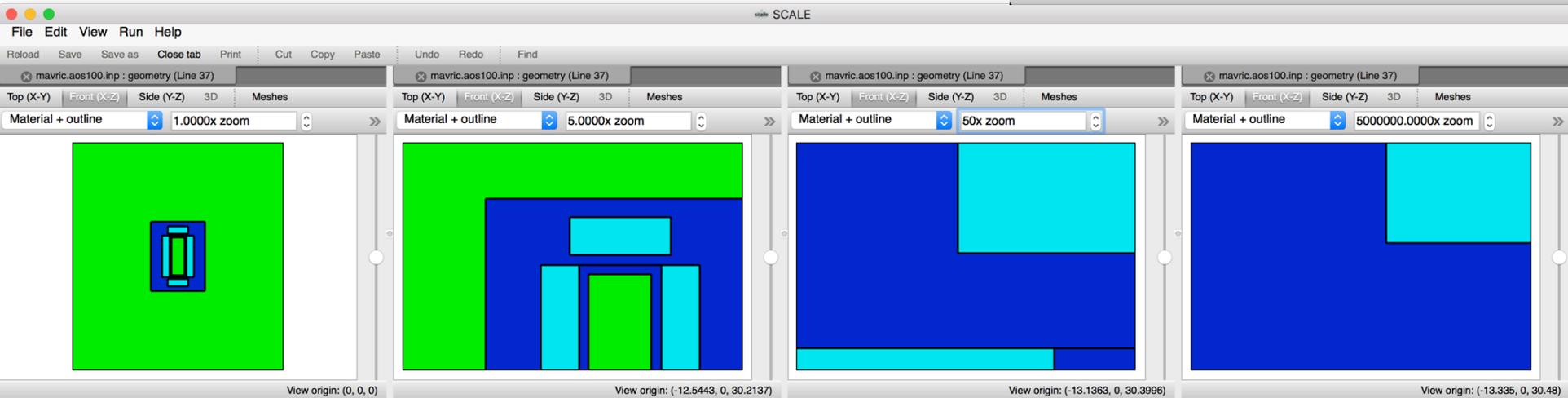
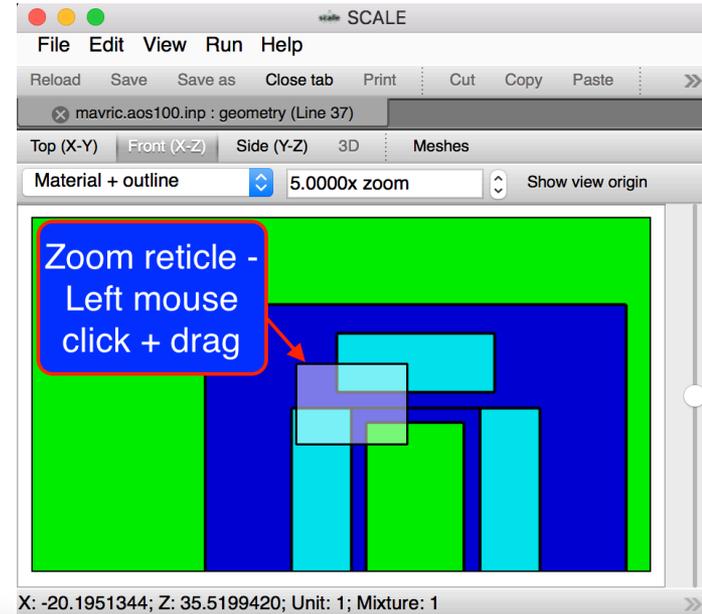


# Geometry Magnification (Zoom)

Ray traced geometry rendering allows for significant magnification.

- Specific value typed by user.
- Incremented or decremented via zoom editor spinner controls.
- Visually specified via a user-drawn zoom reticle.
  - Left click and drag down and to the right.

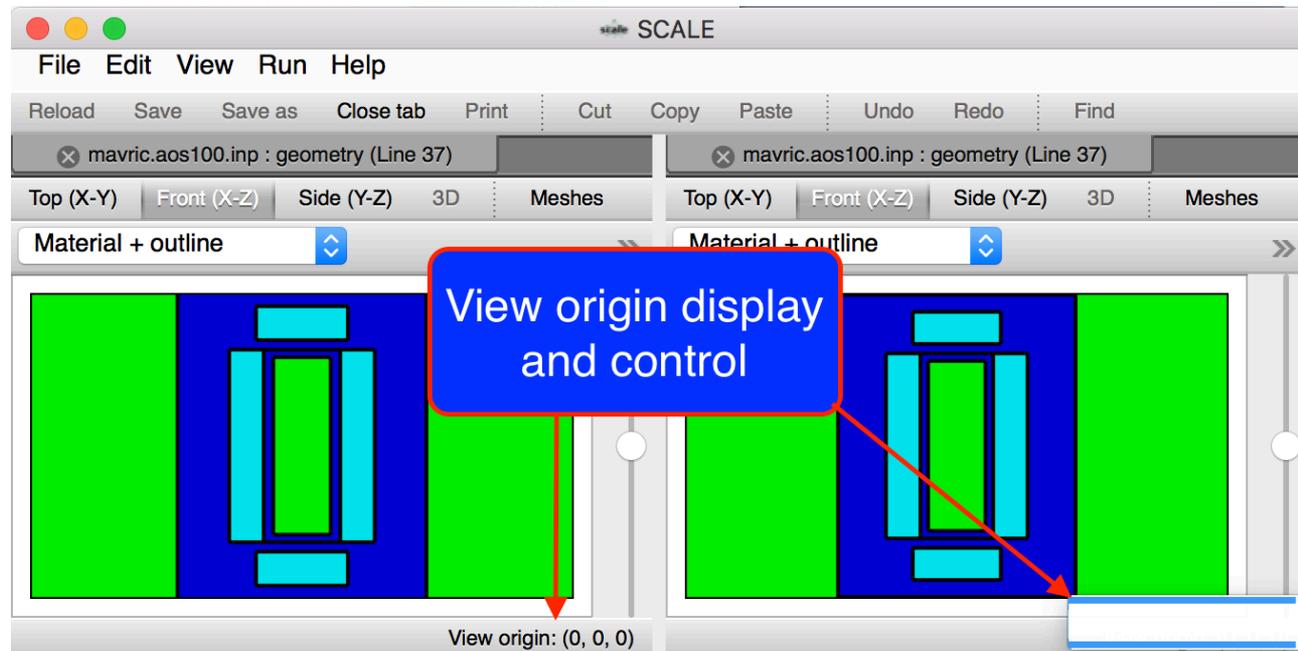
5000000.0000x zoom



# Geometry View Origin Display and Control

Often when geometry errors are encountered, an X,Y,Z position is included in the error message. The ability to quickly navigate to this location and inspect the geometry is facilitated by the view origin control.

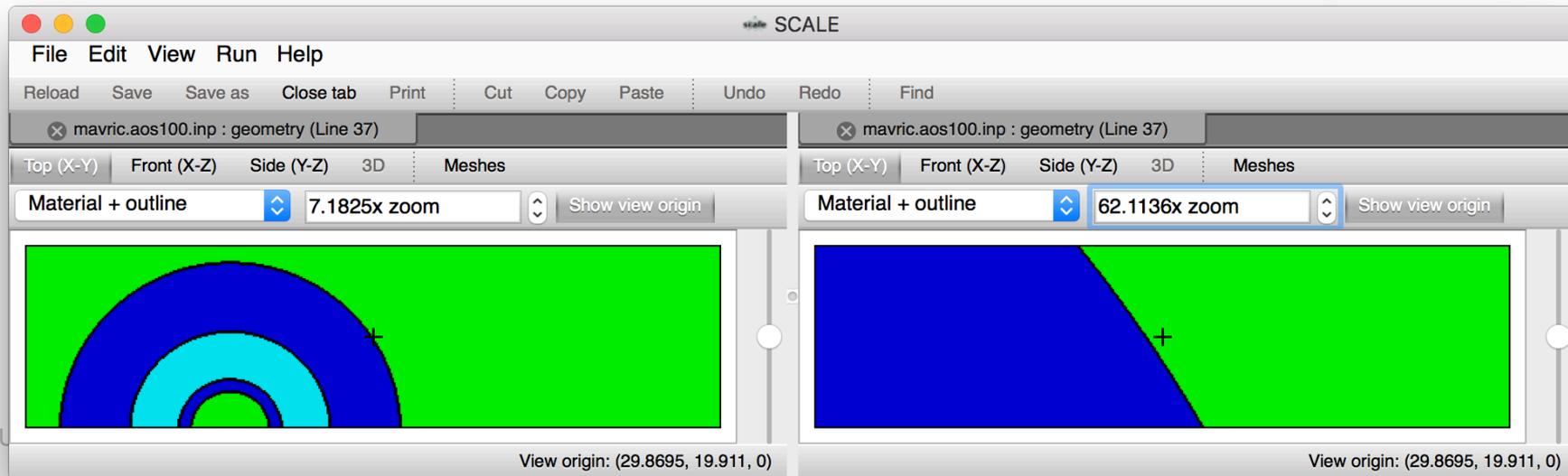
- Left click the View origin display to activate X,Y,Z entry.
- 3 Modes of Origin input
  - Single value : Updates the view plane elevation (axis intersect – same as slider control).
  - Two values : Updates the view plane 2D origin (pans the image).
    - Top (X-Y) – sets the X and Y coordinates of the origin.
    - Front (X-Z) – sets the X and Z coordinates of the origin.
    - Side (Y-Z) – sets the Y and Z coordinates of the origin.
  - Three values : Updates the view plane elevation and the view plane 2D origin.
- Double Left click centers the view origin at the point clicked.
- Useful when combined with the Show View Origin.



# Show View Origin

With ray traced geometry rendering allowing significant magnification, it can be difficult to focus on a specific location. The Show view origin button was added to unambiguously display the location of the view's origin.

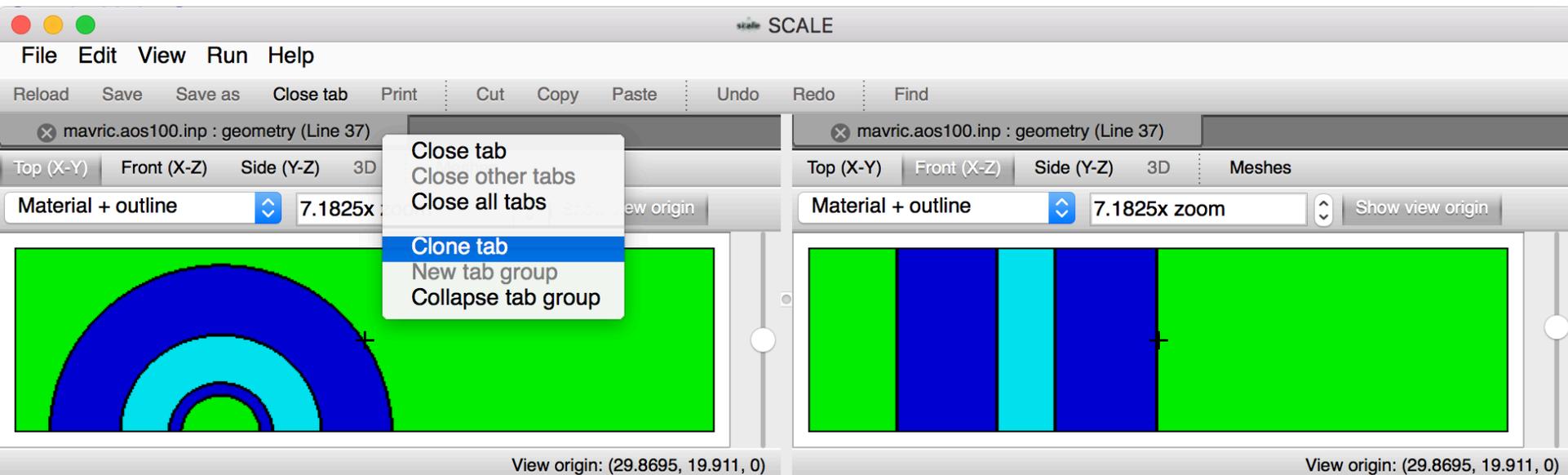
- Very useful when debugging geometry at a given location.
  - Enter the location via the view origin control.
  - Show the view origin.
  - Magnify as needed.



# View Origin Preserved Across View Plane

The geometry viewer is often used for geometry verification and debugging. Both typically involve known locations – X,Y,Z of lost particle, etc.

- View origin is preserved during view plane changes (Top to Front, etc.)
  - Facilitates quickly identifying locations where initial view plane is epsilon ( $1e-15$ ) off a tangent surface.
- Cloneable geometry viewer with subsequent view plane change allows quick visual comparison of location.



# Geometry Errors : Undefined Space

Undefined space lacks any geometry specification. This typically happens when a space is not accounted for with a material statement.

- Cursor information lacks mixture information.
- Undefined space is rendered with grey stripes.

```
1 =csas6
2 Simple pin cell demonstrating geometry error
3 ce_v7.1
4 read comp
5   uo2 1 end
6   h2o 2 end
7 end comp
8 '-----
9 ' Simple pin geometry demo
10 '-----
11 read geometry
12   global unit 1
13   com="Fuel pin 1"
14   zcylinder 10 0.54 0.0 14.28
15   cuboid 20 -0.63 0.63 -0.63 0.63 0.0 14.28
16 ' MISSING media statement referencing zcyl 10
17 ' media 1 1 10 <-- needed
18   media 2 1 20 -10
19   boundary 20
20 end geometry
21 end data
22 end
```

Undefined space :  
zcylinder 10 not  
referenced in media

Undefined space  
displayed as striped grey  
region with no mixture  
listed on mouse over

Line: 17, Col: 39 /csas6/geometry/global\_unit/scale\_comment Validation X: -0.0497938; Y: -0.0541237; Unit: 1; Comment: "Fuel pin 1"

# Geometry Errors : Double-Defined Space

Double-defined space has more than a single geometry specification for a give space. This typically happens when a space is not excluded appropriately.

- Cursor information lists multiple mixtures.
- Double-defined space is rendered using alternating striped mixture colors.
- **NOTE** : the tangent planes of adjacent regions can appear as double-defined space but are infinitely thin.

```
1 =csas6
2 Simple pin cell demonstrating geometry error
3 ce_v7.1
4 read comp
5   uo2 1 end
6   zirc 2 end
7   h2o 3 end
8 end comp
9
10 ' Simple pin geometry demonstrating geometry error
11 -----
12 read geometry
13   global unit 1
14   com="Fuel pin 1"
15   zcylinder 10 0.54 0.0 14.28
16   zcylinder 20 0.64 0.0 14.28
17   cuboid 30 -0.75 0.75 -0.75 0.75 0.0 14.28
18   media 1 1 10
19 ' media 2 1 20 -10 <-- needed
20   media 2 1 20
21   media 3 1 30 -20
22   boundary 30
23 end geometry
24 end data
25 end
```

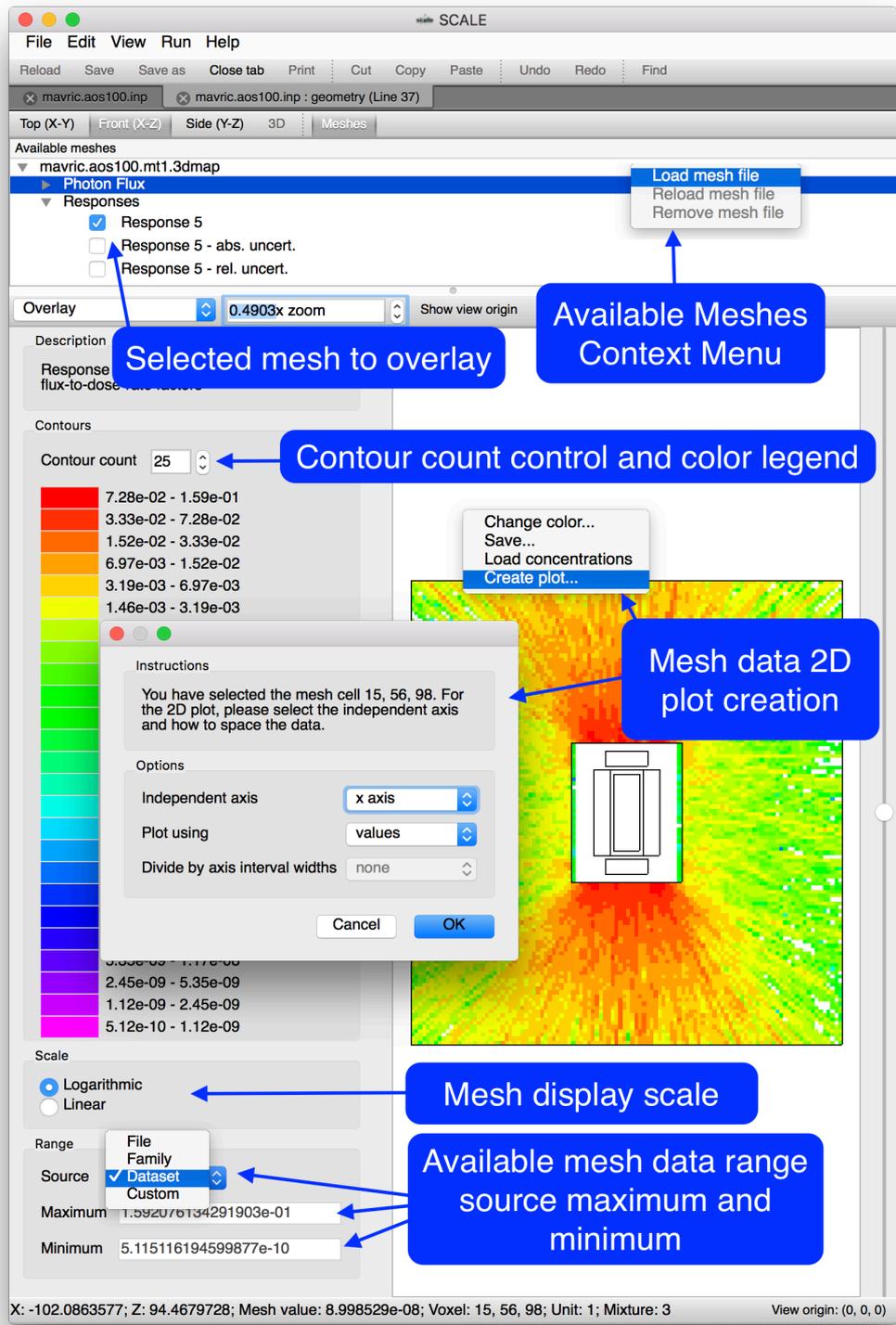
Double-defined space displayed as alternating striped material color and multiple mixtures

Double-defined space: zcylinder 10 and 20 overlap

Line: 19, Col: 42 /csas6/geometry/global\_unit/scale\_comment Validation Messages X: -0.0489691; Y: 0.0103093; Unit: 1; Comment: "Fuel pin 1"; Mixture: [1, 2] View origin: (0, 0, 7.14)

# Mesh Overlay Overview

- Loading Mesh Data.
  - Supported formats (see slide 89).
- Render Modes.
- Contours and color legend.
- Scale – Log and Linear.
- Range – File, Family, Dataset, or Custom.
- Position, Mesh value, Mesh Voxel, Unit, and Mixture under Cursor.
- Context Menu.
- 2D Plot creation.

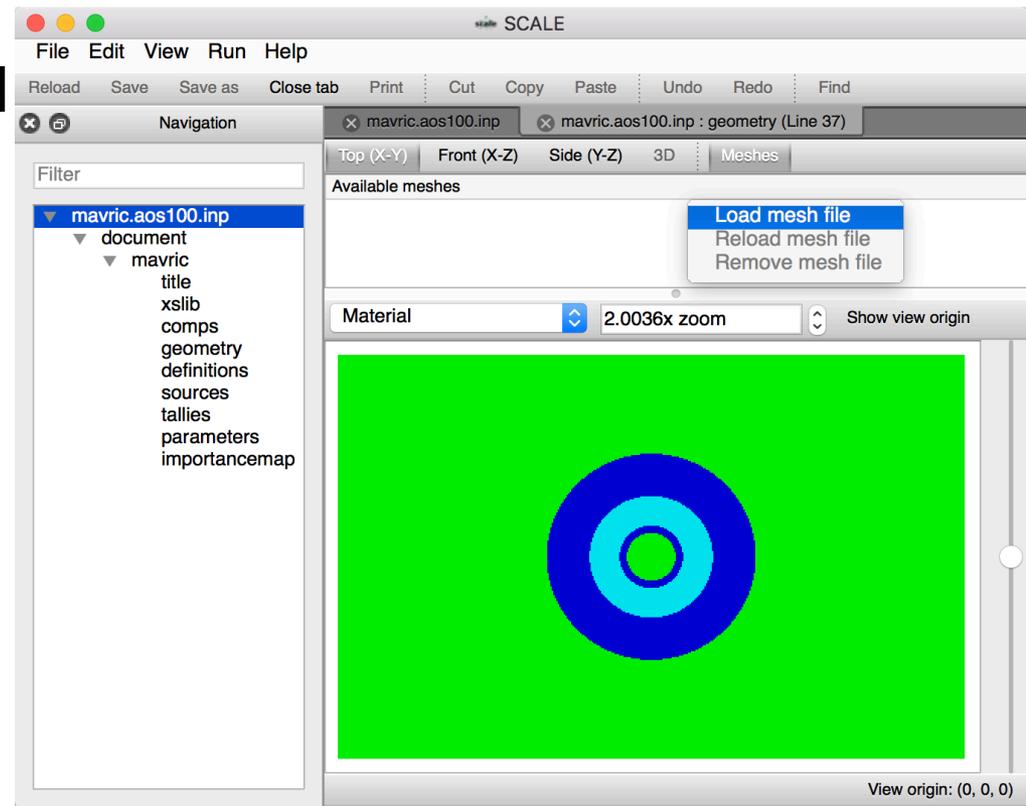


# Mesh Overlay : Loading Mesh Data

With the available Meshes window open, a context menu is available via right click. This context menu will allow loading new, and removing or reloading existing mesh files.

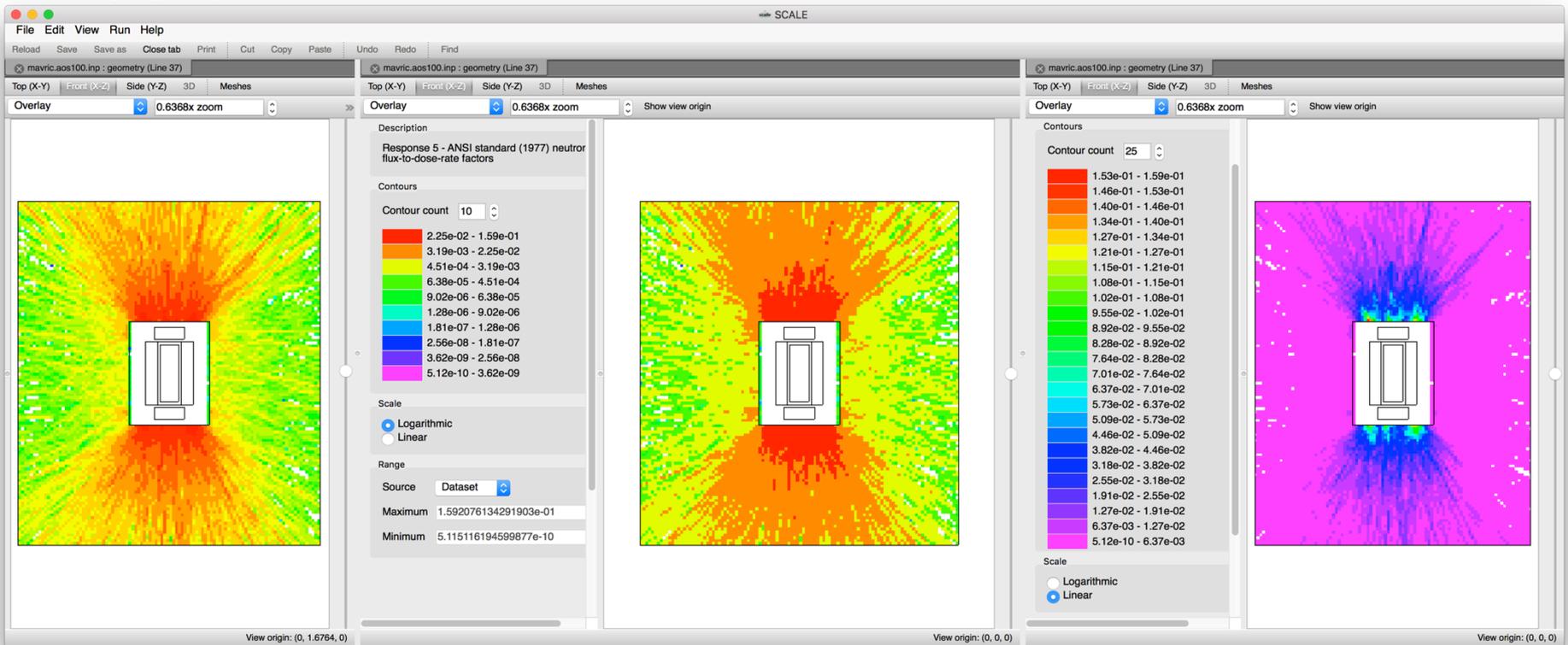
- Right click in Available meshes to access Load mesh file dialog. Select the mesh to load.
- Most of SCALE's major mesh formats are supported

✓ Supported files (\*.3dmap \*.mim \*.msm \*.dff)  
Mesh files (\*.3dmap)  
Mesh importance files (\*.mim)  
Mesh source files (\*.msm)  
Denovo flux files (\*.dff)



# Mesh Contours, Color Legend, and Scale

- Controls influenced by MAVRIC's MeshView plot program.
- Allows changing contour count from 25 to 2 enhancing data contrast.
- Can improve print quality for black and white printouts.
- Linear and logarithmic scale data display.



# Mesh Overlay : Data Ranges

The overlaid dataset's data range can be selected as the file, family, dataset or as custom user-specified.

- The file indicates the entire mesh file context.
- The family range provides context to a selected dataset.
- Custom allows down-selection.

Available meshes

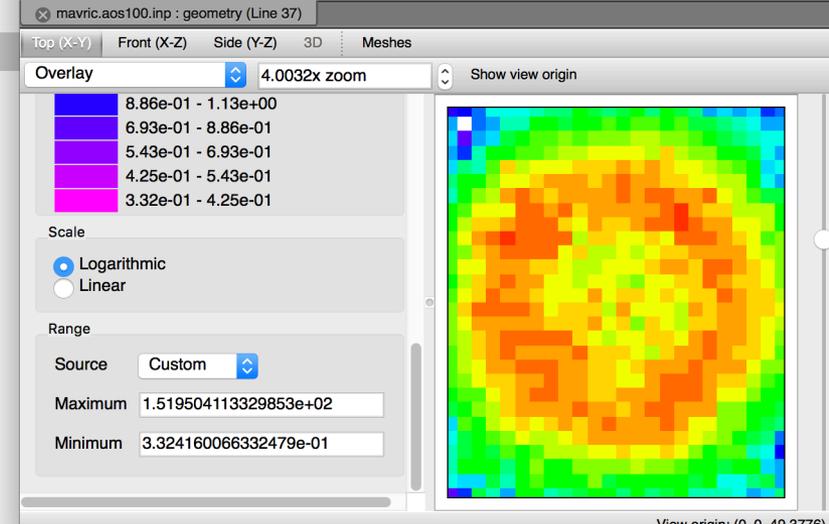
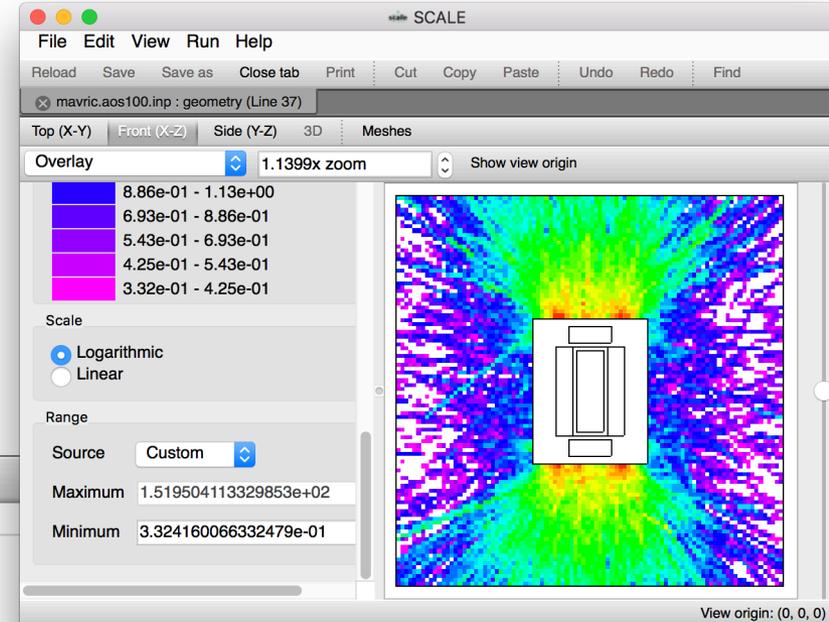
- ▼ mavric.aos100.mt1.3dmap
  - ▼ Photon Flux
    - group 1
    - group 1 - abs. uncert.
    - group 1 - rel. uncert.
    - group 2
    - group 2 - abs. uncert.
    - group 2 - rel. uncert.

Range

Source **Dataset**

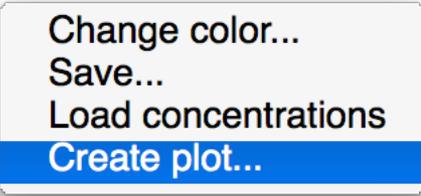
Maximum 1.519504113329853e+02

Minimum 3.324160066332479e-07



# Mesh Overlay : Integrated 2D Plot Creation

Mesh data can be further investigated via the integrated 2D plot creation capability. 2D Plot creation is available via the Create plot popup context menu.



- Plot options include

- Independent axis
  - Cartesian X,Y, and Z.
  - Cylindrical Radial, Theta, and Z.
  - Group when group-wise data is available.
- Plot using values or indices.
- When data is group-wise axis interval widths can optionally be divided linearly or logarithmically.

A screenshot of the SCALE software interface. The main window shows a 3D mesh overlay on a top-down view. A context menu is open over a specific mesh cell, with the 'Create plot...' option selected. A blue callout box points to this menu with the text: '1. Locate point of interest. Right click and select Create plot...'. Another blue callout box points to the 'ChartOptions' dialog box with the text: '2. Configure plot options and click OK. The MAVRIC Chart file will be generated.' A third blue callout box points to the 'document' tab in the chart window with the text: '3. Selection of Chart document will display 2D plot values with uncertainties.' The 'ChartOptions' dialog box shows 'Independent axis' set to 'x axis', 'Plot using' set to 'values', and 'Divide by axis interval widths' set to 'none'. The 'document' tab shows a list of chart options, with 'ygridlines true' highlighted. The bottom window shows a 2D plot titled 'x axis plot at a=0, b=47.7493 generated on Mon Oct 17 14:45:03 2016'. The plot shows 'Photon Flux' on a logarithmic y-axis (0.001 to 100) versus 'x axis' on a linear x-axis (-120 to 120). The plot contains a single data series labeled 'series 1' with error bars.

# Geometry Viewer : Future Features

- 3D Ray traced visualization.
  - Material Transparency.
  - Geometry Culling Surfaces (similar to Keno3D cutaways).
  - Mesh Overlays.
- Geometry view to Input material definition quick view.
  - Allows display of input that creates the material under the cursor.
  - Allows display of isotopic number densities that compose the material under the cursor.
- Geometry view to Input region definition quick view.
  - Allows display of input region/media statement that creates geometry under cursor.
- Visualize any unit on-demand with an optional nesting level.
  - Allows investigating single geometry units with limited depth/complexity.
- Enhanced input and geometry coupling.
  - Display grid/cylinder geometry prior to job execution.
  - Display detector/source locations prior to job execution.

# Summary

- Geometry Viewer Overview
- Activating the Geometry Viewer
- Viewer Controls
- Axis Views
- Render Modes
- Geometry Magnification
- View Origin
- Show View Origin
- View Origin Preserved Across View Plane (Top to Front, etc.)
- Geometry Error Presentation
- Miscellaneous Features
- Mesh Overlay Overview
- Mesh Overlay Supported Formats
- Mesh Overlay Controls
- Future Features
- Questions?